THE GEOGRAPHY OF WORLD AIR TRANSPORT

By
J. PARKER VAN ZANDT

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America Faces the Air Age

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PREFACE

Only at rare intervals in world history does so revolutionary an instrument as the airplane appear. The art of flight introduces a new element into human affairs, a fundamental revision in the ways of mankind. The phenomenal role which aviation has played in the present war has stirred popular imagination as to its potentialities. It is regarded as an open sesame to a new world.

Nevertheless the difficulties in the way of realizing aviation's rich promise are admittedly great. In reducing the globe to manageable size it has made world conquest by a potential dictator technically possible and successful rebellion difficult. Thus we shall be dominated by the threat of aviation in the postwar world, unless some way can be found to direct its future employment and evolution towards socially beneficial ends.

To aid constructively in the solution of this basic problem, the Brookings Institution last year initiated a program of economic research in aviation. Under the general title "America Faces the Air Age," a series of small volumes, bearing particularly on aspects of international air transport, are planned for publication during the coming months.

This introductory volume—*The Geography of World Air Transport*—is limited strictly to outlining the basic setting of the world air transport problem. It reappraises our conventional ideas of geography and transportation economics, and seeks to uncover some of the bedrock of fact on which international air policy should be based. Succeeding volumes will consider the relation of civil aviation to the preservation of peace, the organization and regulation of world air transport, subsidies, and related problems.

These studies are under the direction of Dr. J. Parker Van Zandt, pioneer airline economist and executive, and aviator in the First World War. Mr. Van Zandt, now a regular member of the Institution's staff, helped to prepare the original Air Commerce and Air Mail Acts in the early twenties; has served as aviation adviser to the Civil Aeronautics Board and other government agencies; has flown over most of the airlines of the world; and brings to his task a varied and intimate knowledge acquired in more than two decades of practical aviation experience.

In the development of this study the author has had the assistance of a co-operating committee consisting of Dr. Cleona Lewis, Dr. Louis Marlio, and the undersigned.

HAROLD G. MOULTON
President

The Brookings Institution
May 1944

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J. Parker Van Zandt

THE BROOKINGS INSTITUTION

The Brookings Institution—Devoted to Public Service through Research and Training in the Social Sciences—was incorporated on December 8, 1927. Broadly stated, the Institution has two primary purposes: the first is to aid constructively in the development of sound national policies; and the second is to offer training of a supergraduate character to students of the social sciences. The Institution will maintain a series of co-operating institutes, equipped to carry out comprehensive and inter-related research projects.

The responsibility for the final determination of the Institution's policies and its program of work and for the administration of its endowment is vested in a self-perpetuating board of trustees. It is the function of the trustees to make possible the conduct of scientific research under the most favorable conditions, and to safeguard the independence of the research staff in the pursuit of their studies and in the publication of the results of such studies. It is not a part of their function to determine, control, or influence the conduct of particular investigations or the conclusions reached; but only to approve the principal fields of investigation to which the available funds are to be allocated, and to satisfy themselves with reference to the intellectual competence and scientific integrity of the staff. Major responsibility for "formulating general policies and co-ordinating the activities of the various divisions of the Institution" is vested in the president. The by-laws provide also that "there shall be an advisory council selected by the president from among the scientific staff of the Institution and representing the different divisions of the Institution."

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CHAPTER I

THE PRINCIPAL HEMISPHERE

Most of us have a mental picture
of a world that isn't so.

Our ideas of the world are largely based on a map devised 375 years ago. Invented in 1569 by a Flemish geographer whose Latinized name was "Mercator," it was a wonderful map in its day and still is unsurpassed for certain purposes.

But used as a pictorial likeness of the earth we live on, the Mercator world map and other similar projections have done immense harm. Their grotesque distortions have colored our international thinking, fostered isolationism, and warped our outlook for generations.

A globe has three dimensions, a map two. When you squeeze out the third dimension you are bound to introduce distortions. The type of projection employed determines the nature and extent of the distortions.

In Mercator-type maps errors in size, distance, and direction can be serious enough, but the misrepresentation of continental relationships is the falsehood that has done the most harm. Mercator wall maps have hung before us so long in classrooms, lecture halls, and offices that their untruths are in our very blood.

On a Mercator world projection Greenland appears larger than the continent of South America, whereas actually it is only one ninth as large. Spitsbergen is exaggerated 36 times in size.

As to direction, the shortest route from Rio de Janeiro, Brazil to Darwin, Australia appears to be westward; actually the direct route passes near the South Pole. Chungking appears west of New York; actually the direct route is due north—South.

As to distance, Los Angeles is actually nearer Moscow than it is to Rio de Janeiro. Chicago is nearer Istanbul, Turkey, on the Dardanelles, than it is to Buenos Aires, capital of Argentina.

A Mercator map, as Prof. Stewart has well said, is not a picture but a mathematical symbol, "a representation in code; specifically the 'Mercator Code.'" Because this code shows true compass directions it is an ideal *regional* chart for ship navigators. But this is not

true of the *world* map. World maps are not used as nautical charts in practical navigation at sea.[1]

Any flat map of the entire world, no matter what the projection, involves great distortion.

If, then, the Mercator world map is so misleading, why do we continue to use it? Partly from habit, partly from inertia. We have grown so used to its distortions that the truth now seems false. To change involves effort and inconvenience. But to what better *can* we change?

In correcting Mercator's untruths, others possibly equally grave are introduced. Many ingenious suggestions have been made, but the fundamental dilemma remains: no continuous flat map can present a satisfactory facsimile of the surface of an entire sphere.[2]

As much as half a world can be pictured reasonably well by several different projections.

Beyond a hemisphere, however, the surface of the earth curves inward, while the map perforce continues to spread outward with the unavoidable result that some interruption becomes inevitable, while the distortions grow unrealistically large.

Now a great deal of the earth's surface contributes very little to the vast majority of people on earth—Antarctica, for example, and the southern extremes of the Atlantic, Pacific, and Indian Oceans. If it were possible to compress "all the world that matters" into a single hemisphere, we could project on a sheet of paper a likeness of

[1] See John Q. Stewart, "The Use and Abuse of Map Projections," *Geographical Review* (October 1943), p. 589; also, Hubert A. Bauer, *Globes, Maps and Skyways* (1942), p. 28.

Other projections somewhat like Mercator's, such as Van der Grinten's, are almost equally misleading as far as representing continental relations correctly. "About the best that can be said is that they are not quite so bad as the evil Mercator." J. Paul Goode, *Goode's School Atlas* (1939), p. xii.

[2] Various forms of interrupted or non-continuous world maps have been proposed, some of which (such as Goode's) are excellent for certain purposes. Others which can be reassembled into a shape resembling a sphere are the "dymaxion globe" of R. Buckminster Fuller, *Life*, Vol. 14, March 1, 1943, p. 43 and the "Likaglobe" of Irving Fisher, *Geographical Review* (October 1943), pp. 605-19.

Richard Edes Harrison's "One World, One War," (map) *Fortune*, (Suppl.) Vol. 26 (March 1942), and Rand McNally's "Air Age Map of the World" (1943) are azimuthal equidistant maps centered on the North Pole.

Unfortunately, the interruptions in non-continuous world maps and the grotesque distortions in the others as the distance from the center increases beyond the equator renders them of limited value in presenting a pictorial likeness of the world. "The problem of showing the sphere on a single sheet is intractable." Arthur R. Hinks, *Map Projections* (1921).

such a half-world that would be fairly satisfactory, for most practical purposes. No such hemisphere, of course, exists. Astonishingly enough, however, there is a hemisphere which very closely approximates it, as we shall see.

Hemispheres are what you make them.

Stick a pin at random into the globe. With the pin as a center, draw a line around the globe at a distance away from the pin equal to halfway to the point directly opposite, around the circumference. You have defined a hemisphere.

It is a perfectly valid hemisphere; the pin is its pole and the line you drew is its equator. There is obviously no limit to the number of such hemispheres that can be drawn, depending upon where you happen to stick the pin.

In fact, there is nothing particularly sacred about any hemisphere, even the Western Hemisphere. West of what? No pair of meridians 180° apart makes a logical division for a Western Hemisphere. The so-called "Western Hemisphere" is actually nothing more than an antiquated nineteenth century political concept that has outlived its original usefulness.

If the imaginary line between the "Eastern" and "Western" hemispheres is taken as the longitude at 20° west, then some of Greenland is excluded, while the Azores and Cape Verde Isles are included. On the Pacific side the corresponding dividing line includes part of Siberia, Guadalcanal, and all of New Zealand in the so-called "Western Hemisphere." If another meridian is chosen to avoid excluding part of Greenland, it throws a thousand miles of African shoreline into the Western Hemisphere. These anomalies have troubled geographers for 120 years, ever since President Monroe sent his famous message to Congress December 2, 1823, of which the Monroe Doctrine was a part.[3]

The mistaken idea that North America lies somewhere between Europe and Asia has developed from the pernicious habit of stretching the world out, Mercator-fashion, in an east-west direction. Actually, of course, there are no separate continents of Europe and Asia. The two are one solid body, the greatest continuous mass of land on the

[3] See "The Line of Demarcation Between the Eastern and Western Hemispheres," letter from S. W. Boggs, Geographer, U. S. Dept of State, to Hon. Edith Nourse Rogers, June 8, 1940, *Congressional Record*, daily ed., June 10, 1940, pp. 11963-64; also Lawrence Martin, "The Geography of the Monroe Doctrine and the Limits of the Western Hemisphere," *Geographical Review*, Vol. 30 (July 1940), pp. 525-28; also Vilhjalmur Stefansson, "What Is the Western Hemisphere?" *Foreign Affairs*, Vol. 19 (January 1941), pp. 343-46.

face of the earth. It would be equally correct to affirm that the continent of Europe and Asia lies *between* the east and west coast of the United States, as to say that North America lies between the east and west coast of the Eurasian Continent.

This continued misleading emphasis on East and West arises largely from our constant reference to a map originally designed four centuries ago for mariners in sailing ships. In this respect we are still living in the sixteenth century.

Most of the world that matters lies in one hemisphere.

Now stick your pin in the globe at a point on the earth's surface just southeast of Nantes, in western France. With that as the center, or pole, draw a circle distant halfway to the point directly opposite, around the world. You have defined the hemisphere pictured on the inside front cover of this book.

Within this hemisphere is almost nine-tenths of all the ice-free land area of the world. This is the half-sphere in which the major portions of the world's natural resources, technical skill, and financial strength are found. Ninety-four per cent of all the people on earth are concentrated in this half. Ninety-eight per cent of the world's industry is carried on here. It is incomparably the most important part of the globe to mankind. I have called it the "Principal Hemisphere."[4]

The fact is, we live in a lopsided world. Land and people are not distributed evenly. An amazing proportion of all human activity and international trade is concentrated entirely in one half of it—the Principal Hemisphere. It isn't "all the world that matters," but it is overwhelmingly most of it. It is the part of the world in which our greatest interests lie.

By geographical accident and the advent of air transportation, Europe holds the prime position in the Principal Hemisphere.

The geographical center of the hemisphere falls in Western

[4] See map on inside front cover. There is nothing new about a hemisphere with the maximum amount of land in it. Long before the art of heavier-than-air flight was discovered, the exact center of such a hemisphere was calculated. One of the most careful determinations was by A. Penck, in 1899, who fixed the pole at 47 1/5° North Latitude, 1 1/3° West Longitude, southeast of Nantes, western France. "Die Pole der Landoberfläche," *Geographische Zeitschrift*, Vol. 5 (1899), pp. 121-26. More recently Erwin Raisz, American geographer, has recalculated and confirmed this location. (The American Geographical Society, Washington meeting, September 1943.)

Europe. The exact position, of course, has no profound significance—no more than that the precise location of the center of population of the United States currently falls in a farmyard in Indiana.[5]

The important factor for the Air Age is the distribution of the world's major trading areas. Europe lies close to the hub. The United States, South America, the Far East, and South Africa on the other hand, lie farther out toward the periphery. This means that from Europe to each of the other principal trading regions the flight distance on the average is less than for any other trade area. Ninety-four per cent of the world market is closer, *on the average*, to Europe than to any other region on earth—well within a quarter of the earth's circumference, that is less than 24 hours' flight away.

Countries located away from the heart of the Principal Hemisphere will have to fly their passengers and cargo farther, on the average, to the world's markets than countries located nearer the center. This fact has more significance to future air transport operations than a similar condition would have in maritime service, since airline operating costs vary more directly with distance.

The strategic position of the United States is also very strong.

Fortunately for the United States, there are two compensating factors of major importance which tend to offset the disadvantage of peripheral location. One is our gigantic industrial development. We represent a large segment of the world market ourselves—about 26 per cent of the total income in the world, 38 per cent of all industrial activity, 14 per cent of all inter-regional imports.[6]

The other is our favorable marine position: Ocean highways are determined primarily by barriers of land or ice rather than by great circle courses. As long as the great bulk of world commodities continues to move by sea, our situation facing two oceans and our bountiful harbors will constitute factors of tremendous importance in our national economy.

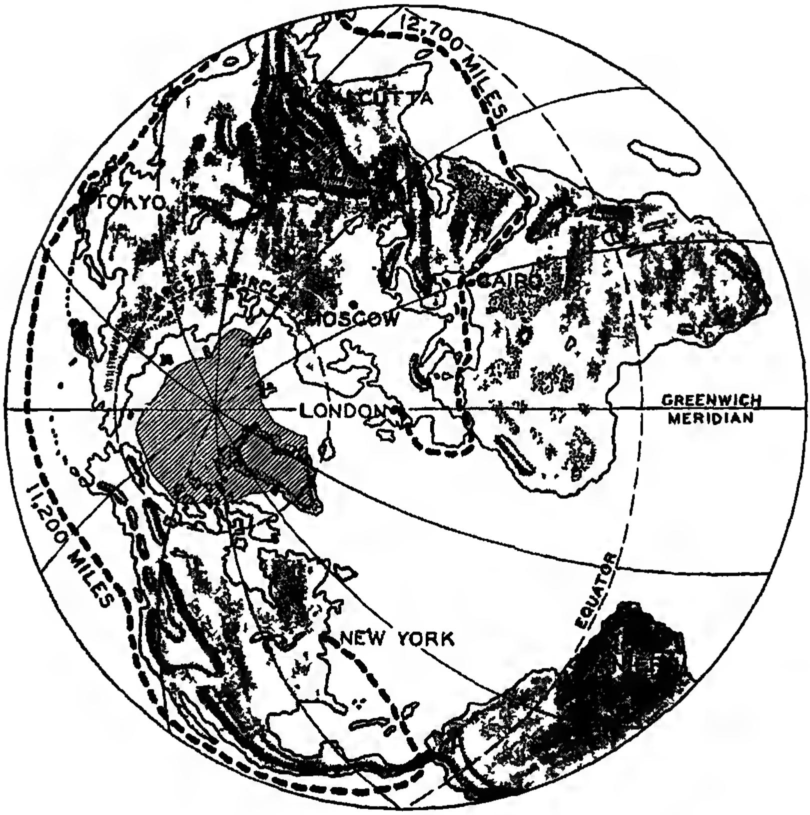
It is nevertheless a basic fact, with respect purely to world air transport operations, that the favored position, if other things are equal, is at the hub of the hemisphere. In the long run we must look to more efficient operations, lower costs through greater volume,

[5] Or that the center of population for the entire world falls in northwest India, near Amritsar.

[6] See charts and tables, Chap. II, pp. 14 to 16.

better "know how," to offset the handicap of somewhat longer average distance by air to the rest of the world markets. The two maps on pages 6-7, contrasting a typical route in the Principal Hemisphere by surface travel and by air, graphically illustrate this.

THE PRINCIPAL HEMISPHERE
Surface Map



By sea New York is 1500 statute miles nearer Tokyo than is London.

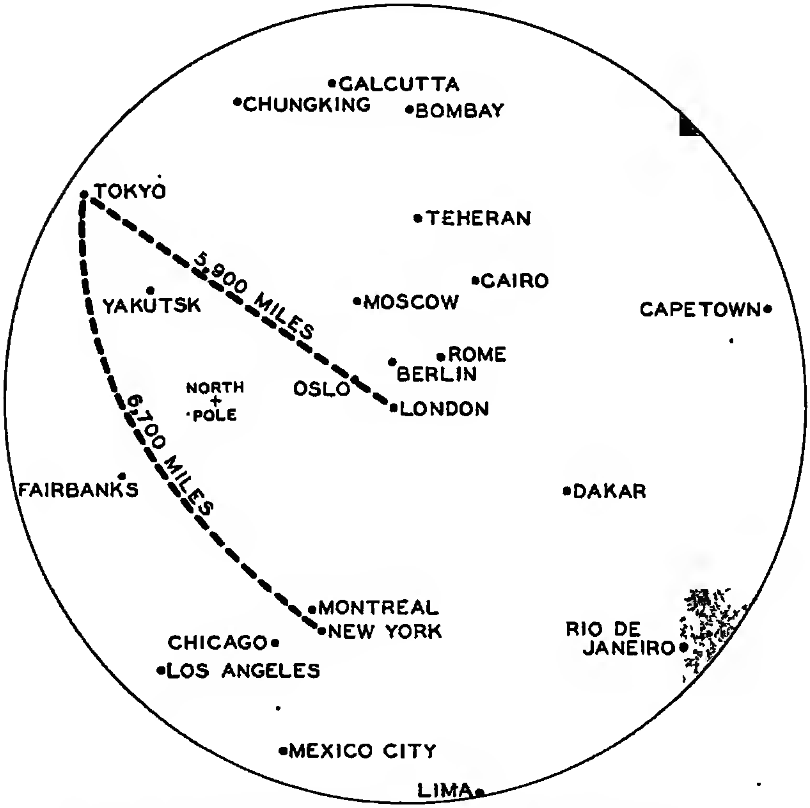
Neither the Pole nor the Pacific figures importantly in the Principal Hemisphere.

Contrary to the prevailing belief, air routes of the future are *not* likely to be laid out across the North polar regions. The Arctic Ocean

is *not* a new Mediterranean, or "middle of the earth" sea. Few, if any, major routes will go as far north as the Arctic Circle.[7]

The mistaken impression that most of the world's land "clusters" about the Arctic Ocean can be quickly corrected by a glance at the

THE PRINCIPAL HEMISPHERE
Air-Age Map



(Routes as drawn above show shortest direct airline courses on this type of projection.)
By air New York is 800 miles farther away from Tokyo than is London.

map on the inside front cover. It would be as reasonable to assert that the center of a person's body was his chin or neck, and to describe his clothes as "clustering" about it.

[7] See discussion of "the myth of great circle flying," Chap. III, pp. 23-24. Also App. A for a quick way to determine graphically the shortest flight path and distance between any two points in the Principal Hemisphere, without computation.

Nor will the Pacific Ocean figure importantly in the trunk air routes of the future. For the shortest flight path between any pair of points in the Principal Hemisphere never leaves that hemisphere. And as the map on the inside back cover shows, the Pacific Ocean lies almost wholly in the other half of the world. *Asia, Africa, the United States and Europe are all part of a single hemisphere.*

At the threshold of the Air Age our primary task is to rid ourselves of inherited Mercator misconceptions and fix in our minds a clear picture of the geography of world air transport.

CHAPTER II

FOUR REGIONS THAT DOMINATE THE WORLD

It is surprising how different the world looks when viewed from a regional perspective.

It is not enough to discard geographical misconceptions. We need a fresh perspective of world trade and industry as well. Prewar frontiers in many parts of the world provide too cramped quarters to employ effectively a vehicle that moves at 200 to 300 miles an hour, or more. When travel is measured in minutes rather than miles, frontiers lose much of their former meaning.

Suppose, then, we disregard the crazy-quilt pattern of some 70 prewar more or less sovereign states and consider the problem on a regional basis. It is surprising how different the world looks when viewed from this broader perspective.

Obviously it is possible to divide up the world in a great variety of ways for various purposes. Our interest here is to discover how basic economic considerations will affect the pattern of future world airways. For this purpose we have grouped world economic activity into a limited number of primary regions.

Consider the world consolidated into eight major trade areas.

Seven of the major trade areas are shown in the accompanying map of the Principal Hemisphere (p. 10). Only one of the eight, Oceania, does not lie in this half of the world. A brief description of each area is given below, and in Appendix B in more detail.

Greater Europe
Including Continental Europe, the British Isles, Turkey, Egypt, and other countries bordering the Mediterranean.

North America
Including the United States, Canada, Newfoundland, Alaska, and Hawaii.

Union of Socialist Soviet Republics (U.S.S.R.)

Asia
Including Japan, the Philippine Islands, and East Indies, but excluding that part of Continental Asia already in Greater Europe and U.S.S.R.

Africa
Excluding the area along the Mediterranean already in Greater Europe.

Middle America

Mexico, Central America, West Indies, and the South American countries facing the Caribbean, including Colombia, Venezuela, and the Guianas.

South America

Excluding the area bordering the Caribbean already in Middle America.

Oceania

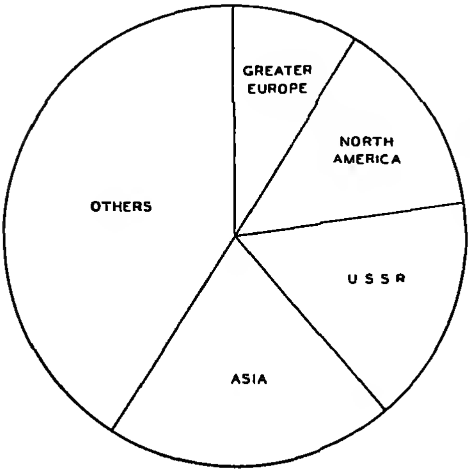
Australia, New Zealand, and other islands in the South Pacific.

The Seven Major Regions of the Principal Hemisphere

Once we avoid breaking the world up into 70 odd political fragments, a very different picture appears. This may be illustrated by the distribution of land, city population, trade, and a few other basic economic factors, expressed on a regional rather than on a national basis. In the following "pie" diagrams the four dominant regions—

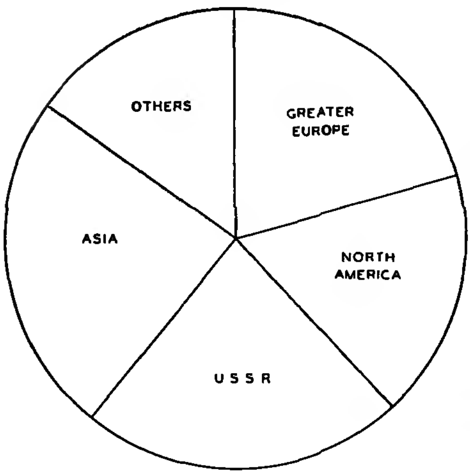
Greater Europe, North America, U.S.S.R., and Asia—are shown separately. The others are grouped in a single segment of the charts. The individual contribution of each region is shown in the percentage table beside the charts.[1]

Distribution of Total Land



Region		Per Cent of World Total
Greater Europe		9.0
North America		14.1
U.S.S.R.		16.0
Asia		20.1
Others:		
Africa	18.5	
Middle America	4.0	
South America	11.8	
Oceania	6.5	
		40.8
World		100.0
British Isles		*0.2*
United States		*5.8*

Distribution of Cultivated Land



Region		Per Cent of World Total
Greater Europe		20.6
North America		17.5
U.S.S.R.		22.6
Asia		24.1
Others		
Africa	4.5	
Middle America	1.8	
South America	6.9	
Oceania	2.0	
		15.2
World		100.0
British Isles		*0.6*
United States		*15.2*

[1] Statistical comparisons on a world scale are in most cases approximations only. This is because accurate, complete, or wholly comparable data are lacking in many cases. Nevertheless it is possible to present a rough picture of the relative importance of the various areas. For data used in connection with the accompanying charts, see App. B.

Seven eighths of the cultivated area is concentrated in four regions having three fifths of the total land area.

The two diagrams, and accompanying figures, on page 11 show the distribution of the total land and of the total cultivated area of the world among the eight major regions. Eighty-six per cent of the world's cultivated land is concentrated in the four regions of Greater Europe, North America, the U.S.S.R., and Asia, which together comprise approximately 60 per cent of the total ice-free land area of the world.

North America, it will be seen, represents about 14 per cent of the world's ice-free land, of which continental United States contributes about two fifths and Canada, Alaska, and Newfoundland three fifths. North America's proportion of the total cultivated area does not differ greatly (17.5 per cent); but in this comparison the United States contributes seven eighths of the total, and Canada, Alaska, and Newfoundland only one eighth.

The U.S.S.R. comprises 16 per cent of the total area and 22.6 per cent of the cultivated area of the world. On both counts it is appreciably larger than the North American region.

Asia (excluding Asiatic Russia) is the largest region, both in terms of total and cultivated area.

Greater Europe (excluding Russia), which represents only 9 per cent of all the land in the world, nevertheless has as much as 20.6 per cent of the total cultivated area. Even though in terms of total area it is much smaller than the U.S.S.R. or Asia, it is nearly equal to them as regards the amount of land under cultivation. Moreover, Europe has a larger cultivated area than North America.

The greatest concentration of the world's urban population is in Greater Europe.

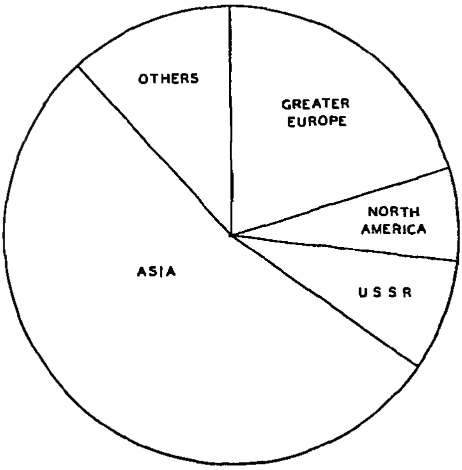
The pair of charts on page 13 show the total population of each region and the number of persons who live in communities as large as 100,000 or over.

Over half of all the people on earth live in Asia. Hardly one in twenty, however, lives in a good-sized city. In North America, on the other hand, 44 per cent are congregated in metropolitan centers. About as many North Americans as Asiatics live in cities of 100,000 population or over.

In Europe live one fifth of the human race and a substantial

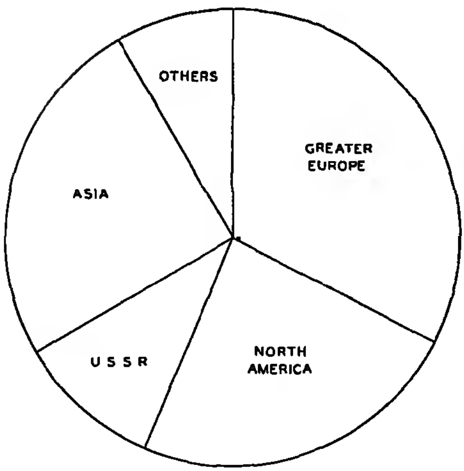
majority of the entire white race. For every North American there are over three Europeans Europe contains almost one third of the big city dwellers of the world. For the same area, as per hundred

Distribution of Total Population



Region		Per Cent of World Total
Greater Europe		20.4
North America		6.7
U S S R		7.9
Asia		53.3
Others		
Africa	5.3	
Middle America	2.5	
South America	3.5	
Oceania	0.4	
		11.7
World		100.0
British Isles		*2.3*
United States		*6.1*

Population in Cities of 100,000 or More

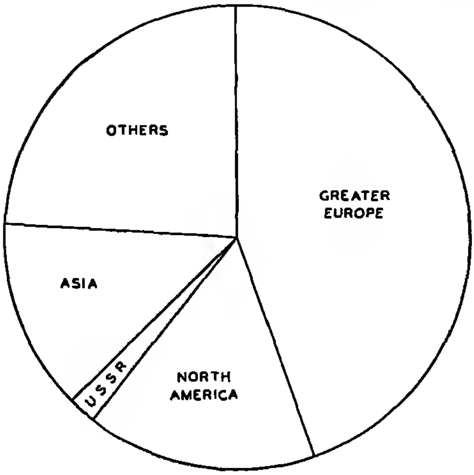


Region		Per Cent of World Total
Greater Europe		32.6
North America		23.6
U S S R		10.3
Asia		25.0
Others		
Africa	0.8	
Middle America	1.7	
South America	4.6	
Oceania	1.4	
		8.5
World		100.0
British Isles		*7.8*
United States		*22.6*

thousand square miles, there are three times as many cities with a population of 100,000 or over in Greater Europe as in North America.

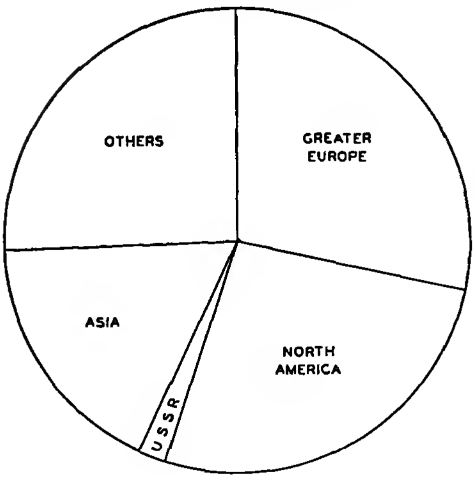
The existence of many metropolitan centers is a factor basically favorable to the growth of air traffic. Big cities as a general rule are important generating centers of air traffic—mail, express, and pas-

INTER-REGIONAL IMPORTS, 1938



Region		Per Cent of World Total
Greater Europe		44.7
North America		16.0
U S S R		1.9
Asia		13.3
Others		
Africa	7.2	
Middle America	5.3	
South America	6.5	
Oceania	5.1	
		24.1
World		100.0
British Isles		*20.0*
United States		*13.7*

INTER-REGIONAL EXPORTS, 1938



Region		Per Cent of World Total
Greater Europe		28.5
North America		26.6
U.S.S.R.		1.9
Asia		17.3
Others:		
Africa	5.0	
Middle America	6.2	
South America	8.5	
Oceania	6.0	
		25.7
World		100.0
British Isles		*11.8*
United States		*21.7*

sengers. But too great a concentration of cities in a small space, as in the British Isles, for example, detracts from the relative merit of interurban air versus surface travel. Air transport needs a reasonable amount of space to demonstrate its services to the greatest advantage.

Greater Europe's import and export inter-regional trade exceeds that of any other region.

In the diagrams on page 14, trade between regions has been segregated from that within each region. In other words, the trade between different countries comprising any region is regarded as domestic for the purpose here in hand.

The striking fact which emerges from these comparisons is that Greater Europe has much the largest total trade with other regions. This is explained in large part by the greater dependency of this highly industrialized continent upon outside sources for both raw materials and foodstuffs. This is the underlying reason why its imports are nearly three times as great as those of the North American region. *Exports* from Greater Europe, on the other hand, are only slightly larger than exports from the North American area.

Europe and North America together account, in round figures, for 60 per cent of all inter-regional imports, and for 55 per cent of all exports. Soviet Russia's share of world foreign trade has been relatively negligible prior to the war—less than 2 per cent inbound or outbound. The trade of Asia with outside regions, in terms both of imports and exports, is comparatively large.

In national income and in industrial output Greater Europe rivals North America.

No one knows exactly the total annual income of the human race. Not only are adequate data lacking in many parts of the world, but no entirely satisfactory basis of comparison has yet been devised. Hence the chart on page 16 must be considered as a rough approximation only.

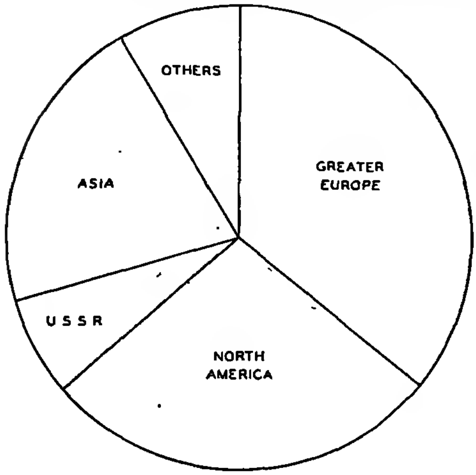
It may be a surprise to see that the total real annual income for Greater Europe substantially exceeds that of North America. Since there are over three Europeans for every North American, however, income *per capita* is less than half as much in Europe as in North America.[2]

Probably 1937 is the last prewar year for which a reasonably satisfactory comparison of world industrial activity can be made. For that year, as indicated by the diagram on page 16, North

[2] About $210 of 1925-34 purchasing power in Greater Europe as compared with $535 for North America. Average income per worker was about $550 in Greater Europe while workers in the United States and Canada averaged $1,380. See App. B, pp 55-57, for details.

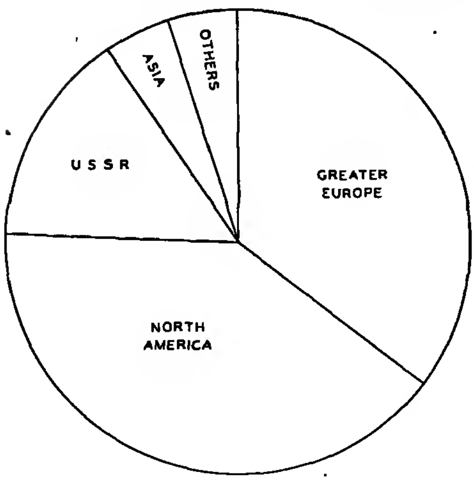
America's factory output exceeded only slightly that of Greater Europe. Between them, they represented over three fourths of the world total.

"NATIONAL" INCOME BY MAJOR REGIONS, 1925-34



Region		Per Cent of World Total
Greater Europe		35.9
North America		27.8
U.S.S.R.		6.9
Asia		20.9
Others:		
Africa	1.8	
Middle America	1.0	
South America	4.4	
Oceania	1.3	
		8.5
World		100.0
British Isles		*8.9*
United States		*25.8*

FACTORY OUTPUT BY MAJOR REGIONS, 1937



Region		Per Cent of World Total
Greater Europe		35.5
North America		40.1
U.S.S.R.		15.0
Asia		4.6
Others:		
Africa	0.7	
Middle America	0.5	
South America	2.3	
Oceania	1.3	
		4.8
World		100.0
British Isles		*8.2*
United States		*38.2*

The extraordinary industrial advance of the U.S.S.R. in the two decades before the war had carried her into third place by 1937, with 15.0 per cent of the world total. By 1938 this proportion had risen to

18 per cent and continued to mount until June 1941, with such fateful subsequent consequences to the Nazis when Hitler plunged across the border of Russia.[3]

North America leads the world in transportation facilities.

As the diagram on page 18 shows, for every mile of railway track in Greater Europe there are one and a half miles in North America. There is more railway trackage in North America than in all the rest of the world outside Europe.

North America, however, is a much bigger place than Greater Europe. In fact, the ratio of land areas is almost the same as the inverse ratio of railway mileages. Hence per square mile of area, the number of miles of track is practically identical in the two regions.

As to the density of use, what scattered data are available suggest that travel on European railroads is much more intensive than in North America.[4] In part, this results from there being so many more Europeans than Americans—they outnumber us three to one. It is also due in part to the far greater use the average American makes of automotive transportation.

This latter factor is heavily underscored by the diagram on page 18. In North America before the war there was 1 motor vehicle to every 4.4 persons on the average; in Greater Europe there was 1 to every 50. In Russia there was a car to every 213 persons; in Asia, 1 to every 1,700.

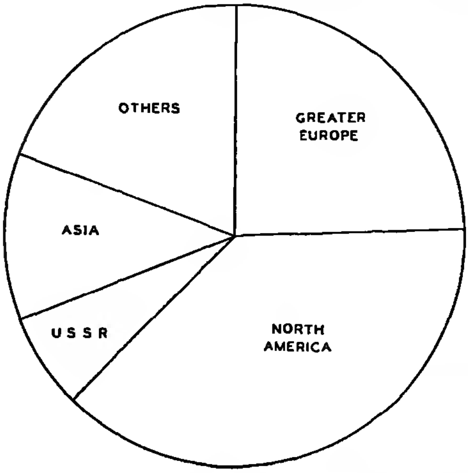
This chart, perhaps more than any of the others, bears eloquent witness to the different "way of life" in the eight principal regions of the world. The number of automobiles a community can (or thinks it can) afford is determined in part by the number of individuals who find themselves left with at least some disposable income, after meeting all the necessities of life—the butcher, the baker, the rent,

[3] In 1937, on a national rather than a regional basis, the U.S.S.R. was second only to the United States in factory output. United States production since that date has of course increased tremendously, under the stimulus of war. Taking 1937 as a base of 100, the average annual index of physical output of United States manufacturing industries had increased to 228 by 1943. (Index numbers converted from 1935-39 base; 1943 from *Federal Reserve Bulletin* (February 1944), p. 180; and 1937 from U. S. Dept. of Commerce, *Survey of Current Business*, 1942 Supplement, p. 7.)

[4] In Germany alone, for example, a country not as big as the single state of Texas, railway passenger-miles in 1937 were substantially more than the entire passenger mileage of the United States (31,128 millions against 24,695 millions). Rail travel is also very heavy in Japan. For additional data on passenger miles see p. 62.

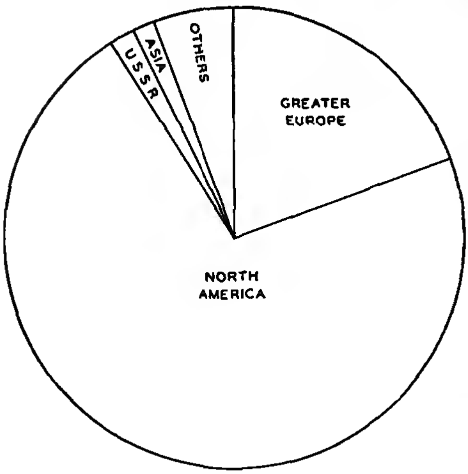
the tax collectors and the like.[5] The number of automobiles also reflects to some extent the "conditioning" of a community to the acceptance of wider transportation opportunities.

World Railway Mileage, 1938



Region		Per Cent of World Total
Greater Europe		24.4
North America		37 9
U S S R.		6.7
Asia		11.7
Others		
Africa	4.3	
Middle America	2.9	
South America	7 9	
Oceania	4.2	
		19.3
World		100 0
British Isles		*3.3*
United States		*32.0*

World Registration of Motor Vehicles, 1940



Region		Per Cent of World Total
Greater Europe		19 5
North America		71.6
U S S.R.		1.8
Asia		1.5
Others:		
Africa	1.2	
Middle America	0.7	
South America	1.3	
Oceania	2.4	
		5.6
World		100 0
British Isles		*5.5*
United States		*68.3*

Thus in this automobile chart we may have a measure—a very rough measure to be sure, but nevertheless some indication—of the

[5] See *The Dynamics of Automobile Demand* (1939), based upon papers presented at a Joint Meeting of the American Statistical Association and the Econometric Society, Dec. 27, 1938; also App. B, pp 63-64.

relative responsiveness of the eight principal regions to the opportunities for world-wide travel which postwar air transport will offer.

It would be very helpful if we could consider this chart a sort of barometer of future air travel. Then we could predict that seven out of every ten passengers on world airlines would be North Americans; that between three and four times as many Americans would fly as Europeans; and that together Greater Europe and North America would account for 90 per cent of future world air commerce!

Unfortunately, no such precision of prophecy is possible. Prediction is not that easy. But it is demonstrably correct to say that North Americans on the average are more "foot-loose" and more blessed with at least some surplus income with which to indulge their travel propensities than are the peoples of any of the other seven regions. As a logical corollary, North Americans are certain to prove the world's best customer for international air transport. Together, residents of Greater Europe and North America are likely to constitute an outstanding majority of passengers on world airlines for a long time to come.[6]

In economic union lies Europe's potential strength.

If Greater Europe ever succeeds in organizing its economy on a regional basis, the results may be little short of revolutionary, not only to the half-billion residents of that area, but to the whole world. A united Greater Europe would excel every other world region in the majority of categories we have listed. It would outnumber, outtrade, and might outproduce the United States in a short time.[7]

[6] In this connection, it is of interest to note that United States citizens and alien residents outnumbered all other travelers by more than 5 to 1 in maritime passenger traffic between the United States and oversea countries during the years 1924 to 1938. Computed from data, adjusted to exclude immigration and emigration, given in the U. S. Dept. of Commerce, *Oversea Travel and Travel Expenditures in the Balance of International Payments of the United States, 1919-38*, Economic Series No. 4 (1939), pp. 38-39.

In international *air* travel, even on routes entirely outside the United States, American travelers were a substantial proportion of the total traffic. On the Dutch airline (K.L.M.), for example, operating between the Dutch East Indies and Europe, via Singapore, India, and the Middle East, United States nationals during 1935-37 ranked third, exceeding any but Dutch and British nationals.

A large proportion of passengers on European air routes were American nationals. In the early years of the London-Paris air service, Americans constituted 75 per cent of the total traffic. "Preliminary Report on British Commercial Aeronautics," prepared for U. S. Army Air Service by Lieut. J. Parker Van Zandt, July 8, 1924, *National Advisory Committee for Aeronautics Technical Memorandum No. 328*, (September 1925), p. 6.

[7] See "Europe: We Missed the Point," *Fortune*, Vol. 24 (December 1941), p. 94.

But unity is not Europe's strong forte. It is a hothouse of nationalisms which Nazi aggression, far from suppressing, has only succeeded in intensifying. Frontiers which to Americans historically have always meant opportunity, to Europeans have more often spelled invasion.

Important as are the British Isles in the economy of Greater Europe, their weight is far from preponderant. Compare, for example, the contribution of the British Isles, Greater Europe, and the United States to the world total as shown in the following table.

	British Isles	Greater Europe	United States
	(Per Cent of world total)		
Total population	2	20	6
Cultivated land	0 6	21	15
Population in cities of 100,000 or over	8	33	23
National income	9	36	26
Inter-regional imports	20	45	14
Inter-regional exports	12	29	22
Factory output	8	36	38
Number of automobiles	6	20	68

Britain's part in every category (except cultivated land) far exceeds the ratio of its population to that of Greater Europe—one person out of every ten. But it does not contribute the lion's share in a single item of the regional totals.[8] As a region, Greater Europe surpasses the United States in all but the last two categories.

Four regions dominate the world.

The degree to which Greater Europe, North America, the U.S.S.R., and Asia dominate the world picture is truly astonishing. Over nine tenths of the world's income is earned in these four regions. Ninety-two per cent of all cities of 100,000 or more are located there. Ninety-five per cent of all manufactured goods are produced there.

This overwhelming preponderance of world population, trade, industry, and income in four principal regions determines the basic

[8] We are speaking here of the British Isles as a geographical unit in the Greater Europe region The chief geographical characteristic of the British *Empire*, on the other hand, is its disunity, with dominions and dependencies scattered all over the Seven Seas. It is a "steamship empire," to borrow H. G. Wells' phrase. See J. F. Horrabin, *An Outline of Political Geography* (1942), p. 103.

pattern of postwar primary air routes. Three of these regions—Greater Europe, the U.S.S.R., and Asia—together constitute one continental area, Eurasia, the fourth, another continent—North America. (See map of the Principal Hemisphere, page 10.)

We may anticipate, therefore, that *airways on and between the Eurasian and North American continents* will carry the heaviest traffic and be the leading routes of the future. This is not to imply

	The "Big Four" Regions (Per Cent of world total)
Factory output	95
Number of automobiles	94
National income	91
Population in cities over 100,000	92
Number of cities over 100,000	91
Total population	88
Cultivated land area	85
Railway mileage	81
Inter-regional imports	76
Inter-regional exports	74
Total land area	59

that airways in or connecting other regions will not also be of great significance. Relatively, however, they cannot have the same importance as those which serve such an overwhelming proportion of the world's economic life as the "Big Four" regions represent.

Turn now in the following chapter to consideration of the aerial gateways to North America through which much of the intercontinental air traffic of the future will flow.

CHAPTER III

THE THREE MAJOR AERIAL GATEWAYS TO NORTH AMERICA

"World history," writes Mr. Horrabin, "is the story of the breaking down of barriers, natural or man-made, and the gradual growth of intercommunication and intercourse between the various peoples of the earth."[1] World air transport offers the possibility of an immense acceleration in this intercourse between peoples heretofore effectively isolated from one another. How far can we foresee the basic pattern of this aerial flow between the principal regions outlined in the preceding chapter?

To draw routes on a map is, of course, an easy thing to do. A pencil will suffice. The very flexibility of flight lends itself to such a process. But a world map covered with a maze of projected airlines leading almost everywhere contributes little but confusion.

Five principal factors will influence the world airway pattern.

However complex the ultimate pattern of inter-regional air transport may become, its development for many years will be determined largely (aside from political aspects) by the interplay of five factors:

(1) Potential traffic, between terminals and along the route;
(2) Availability of adequate airports, airway aids, and facilities;
(3) Longest unavoidable non-stop flight;
(4) Length of route;
(5) Flying weather.

Naturally many of the technical details of specific routes cannot properly be discussed while we are still in the midst of a global war. It is appropriate, however, to consider certain basic principles which underlie rational consideration of future aviation policy.

Accordingly, we have drawn on the map on page 23 a pattern of the paths along which the major part of future world air traffic will probably flow. This is of course a simplified schematic chart. It does not purport to plot specific airways in detail. Rather, it illustrates the broad underlying pattern of air flow which may be

[1] J. F. Horrabin, *The Opening-Up of the World.* The World Today Series (April 1936).

expected to develop between the eight primary trade regions of the world.[2]

Aircraft in scheduled service do not normally fly great circle courses.

However practically desirable, aircraft in regular transport opera-

THE PRIMARY PATTERN OF WORLD AIR TRAFFIC
IN THE PRINCIPAL HEMISPHERE

[2] It should be emphasized again that none of the maps shown is free from distortion. No flat map is; "Because maps lie flat, they lie." The courses outlined here are drawn along great circles; from Greater Europe they approximate straight lines and fan out like spokes of a wheel; elsewhere they curve outward.

Perhaps the best way to make mental allowance for the unavoidable differences in scale and area between the central and outer portions of the Principal Hemisphere map used throughout this book is to imagine it printed on a rubber membrane which could be held firmly by a ring at the rim and blown up into the shape of half a ball. Then everything would appear more nearly in correct size, shape, distance, and relative location. Another way is to think of it as drawn on the inside of a large

tion do not ordinarily fly great circle courses;[3] they fly from airport to airport along established airways. Thus a practical comparison of the total flight distance along alternative routes involves adding together the individual stages flown from one airport to the next.

This myth of great circle flying in commercial service is responsible for much confusion over future practicable air transport routes. The trans-ocean airway between San Francisco and Manila, for example, via Hawaii is 8,000 statute miles in length. The great circle distance is only 6,965 miles. But to fly the latter course would involve a non-stop flight over open water for almost the entire distance, passing 1,650 miles north of Honolulu and some 700 miles south of the Aleutian Islands. No transport planes which we can now foresee will be able to make any such non-stop flights on a commercially economic basis.

This same confusion explains much of the misplaced enthusiasm over transpolar routes. Actually, most over-the-pole routes would be little more than *short cuts to nowhere.* Alaska, true enough, is directly across the pole from Moscow, but what of it? How many Alaskans have business in Moscow, or Muscovites in Alaska? The confusion here is confounded by treating a transit point as if it were itself a terminus.

On none of the major airlines of the world will there be occasion to go as far north as the Arctic Circle (66° 32′). Even the Alaskan route to Asia, as we shall see, lies south of the Arctic Circle. Alaska's primary significance on air maps of the future is as a convenient bridge between two great population centers.

The best air route to Asia
is overland.

The distorted ideas of the world to which we have grown so accustomed make it difficult at first to think of Alaska as our major aerial portal to the Far East. Once, however we shake off the mental shackles of the Mercator world map we find ourselves in an unfamiliar and exciting world.

Suppose, for example, we live in California; what would be our shortest air route to Hong Kong, let us say, or to the Dutch East

bowl, or dome, so that what you see is somewhat foreshortened except at the edge. For further comments on maps, see App. A.

[3] That is, the most direct, shortest possible path between two points on the surface of the globe. Technically, all circles upon the earth which divide it into two equal parts are called great circles.

Indies? We might be forgiven for assuming that the most direct course lies across the Pacific Ocean via Hawaii and the other convenient island stepping stones. But we would be wrong.

The shortest practicable airway between the West Coast and Asia is not over the ocean at all, but over the land. How much shorter the overland route is than the transpacific, the following comparison of the length, in statute miles, of the two alternative airways shows.

San Francisco to	Via Overland Airway	Via Transpacific Airway	Overland Airway Shorter by
Shanghai	6,605	9,150	2,545
Hong Kong	7,365	8,740	1,375
Singapore	8,985	9,490	505
Batavia	9,540	9,830	290
Manila	7,755	8,000	245
Longest overwater flight, in miles	60	2,400	2,340

Shanghai is over 2,500 miles closer to San Francisco by the overland route. Hong Kong is 1,357 miles closer. Even Manila is nearer San Francisco by way of Alaska and Shanghai than via the midpacific islands.[4]

A kindly Providence has located our northern territory and the Siberian Peninsula so that the airway over land lies very close to a great circle route between America and Asia. This is pure good fortune, for the closer an airway approximates a great circle, the less is the total distance to be flown.

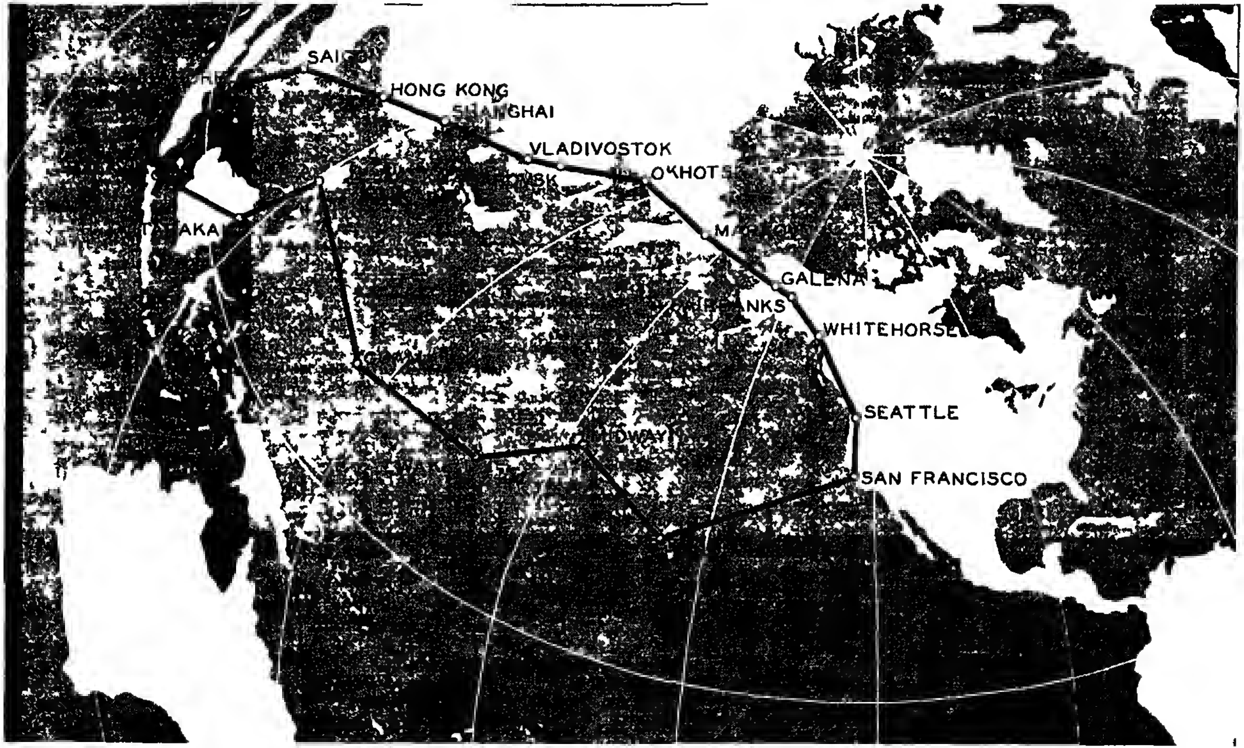
With regard to transocean routes, however, nature in general has not been so kind. Intermediate islands available for airports so essential for economic operation have been scattered inconsiderately in most instances far off the great circle routes of prime importance.

For skeptics who need to be convinced that a point as far south of the equator as Batavia can actually be nearer San Francisco, via Alaska, than by the more familiar transpacific airway, a comparison of actual airport-to-airport mileage is given below and the alternative routes are shown on the map on page 26.

There is a wide range of intermediate airports to choose from on the overland route, whereas alternate ocean bases anywhere near a straight course are very limited. Via Manchuria (Harbin), Peiping, and Hankow, for example, it is just 100 miles longer to Batavia than

[4] There is no intention here to disparage in any way the remarkable pioneering achievement of Pan American Airways in establishing a transpacific airline in 1935; nor to minimize the political factors which among other things prevented establishment of an overland route to Asia at that time.

THE OVERLAND AND TRANSPACIFIC AIRWAYS TO ASIA



Azimuthal equidistant projection centered on San Francisco

via Vladivostock and Shanghai. From Markovo on the Siberian Peninsula via Yakutsk (where Willkie stopped) to Chungking and the marvelous ruins of Angkor in Indo China is only 310 miles farther.[5]

San Francisco, California to Batavia, Netherlands Indies
(Distance in statute miles)

Via Typical Overland Route			Via Transocean Route		
Airport	Intermediate	Cumulative	Airport	Intermediate	Cumulative
San Francisco	—	—	San Francisco	—	—
Seattle	665	665			
Whitehorse, Yukon, Can	1,050[a]	1,715			
Fairbanks, Alaska	490	2,205			
Galena, Alaska	260	2,465	Honolulu, T H	2,400[b]	2,400
Markovo, U S S R	970	3,435	Midway Island, T H	1,305	3,705
Okhotsk, U S S R	915	4,350	Wake Island	1,190	4,895
Khabarovsk, U S S R	845	5,195			
Vladivostok, U S S R	405	5,600			
Shanghai, China	1,005	6,605	Guam	1,510	6,405
Hong Kong, China	760	7,365			
Saigon, Indo China	935	8,300	Manila, P I	1,595	8,000
Singapore, Straits Settlements	685	8,985	Tarakan, Borneo	815	8,815
Batavia	555	9,540	Batavia	1,015	9,830

[a] The longest non stop flight via the overland route for this particular choice of airports is 1,050 miles, the average length of flight is 735 miles By landing at additional intermediate fields, or flying an alternative course, the length of the individual stage can be adjusted to correspond to the most economic operating distance for the particular type of plane employed

[b] The longest non stop flight via the transocean route is 2,400 miles, the average length of flight is 1,405

A plane with an economic range of, say, 1,300 miles could eliminate a number of the intermediate stops listed and shorten the total flying distance via Alaska appreciably. It is thus possible to fly this entire

[5] Wendell L Willkie, *One World* (1943), Chap 5, "The Republic of Yakutsk" It is worth noting that the course of Willkie's "Round the World" flight never left the Principal Hemisphere—that is, one half of the world The same is true of the original U S Army round-the-world flight in 1924, of Post and Gatty's flights, and of Howard Hughes' record circling of the earth in 91 hours in 1938. For most practical purposes "One World" is one-half a world!

journey without ever being farther from land than, say, the width of the Bering Strait, a distance of less than 60 miles.

The airway to Asia via Alaska has the greatest population density.

Since people live on dry land and not in mid-ocean, it would seem almost a truism that an airway entirely overland would probably have a greater population density per mile of route than one which was laid out over thousands of miles of open ocean. The assertion has been made, however, and widely repeated, that the desirability of moving over densely settled regions that originate intermediate traffic will act "to hold the bulk of the world's air traffic to lanes that will not vary greatly from the old sea lanes."[6]

The origin of this curious misconception apparently can be traced to the use of seaplanes exclusively in early intercontinental flights. It was assumed that landplanes would have to follow trails blazed by flying boats.[7]

Alaska and Eastern Siberia, of course, add very little to traffic potentials for some 4,000 miles of the airway connecting Asia and America. On the transocean route, however, this status is even more true for the 2,400 miles of open ocean between California and Hawaii and for the 5,600 virtually uninhabited miles from Hawaii to the Philippines.

If we count only the population of the actual stops shown in the airports listed above, the population density of the airway between San Francisco and Batavia via Alaska is *seven or eight times as great* as that of the transocean route. If all the population along the airway strip between stops is included, the population density per mile flown via Alaska is at least *twenty times as great* as via the ocean island course.

In fact, one of the potent influences in differentiating the air lanes of the future from former sea routes is this very factor of potential intermediate traffic. The most traveled airways from New York to Shanghai, for example, or to Durban, South Africa, are not likely

[6] John Q Stewart, "Map Projections and World Air Routes," *Geographical Review*, Vol 33 (1943), p 598 See also following footnote

[7] See Captain G S Bryan (now Admiral), U S N, "Commercial Oversea Aviation Routes," *United States Naval Institute Proceedings*, Vol 66 (1940), p 1427 "Most of the transoceanic planes at present are seaplanes and in this article it is assumed that this type will be used The use of landplanes would modify this paper only to the extent that we would then examine the various island stops for level ground instead of sheltered water for the purpose of landing and taking off"

even remotely to run parallel to the conventional steamship routes between such ports.

Long non-stop flights mean higher fares.

Perhaps the most important feature of the Alaskan airway to Asia, from a commercial point of view, is the greatly reduced length of the longest non-stop flight imposed. On the transocean route a non-stop stage of 2,400 miles is unavoidable (between Hawaii and the mainland). On the overland airway no flight need be over 1,000 miles.

Of all forms of transportation the airplane is the most sensitive to gross weight, that is, the combined weight of fuel, revenue load, and weight of the empty vehicle. The longer the flight, the greater the amount of fuel which must be carried and the less the revenue load capacity remaining, for a given maximum allowable gross weight.

Each type of transport aircraft, depending on its design, has an upper and lower limit of flight between landings within which it can be operated most efficiently. In general the larger the plane the greater is this range and the higher is the upper limit.

The schematic chart on page 30 illustrates this general relation of cost to length of non-stop flight, for three typical airplanes.

Airplane "A" corresponds to the type of transport planes largely used by domestic airlines in the United States before the war, such as the Douglas DC-3. The curve for airplane "B" represents the performance which may be expected from certain equipment converted from military transport types at the end of the war. Commercial planes of the type of airplane "C" may not be generally available until sometime after the war.

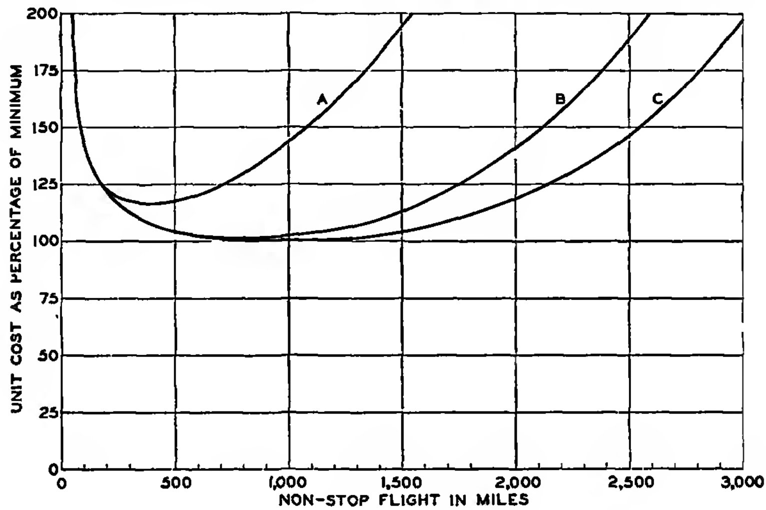
As the chart shows, the optimum non-stop length of flight for maximum economy of operation is not likely to exceed 1,700 miles for some years to come. For immediate postwar operations a non-stop range of well under 1,500 miles will probably be preferable. Beyond these ranges economic penalties accumulate rapidly for the type of transport equipment we can now foresee in the near future.

Aircraft can of course be designed to fly almost any distance. It is possible our whole conception of economic flight distances will have to be revised when radically new developments such as flying wings and jet propulsion become commonplace. While, however, the present type of aircraft remains standard, a lower operating cost per revenue ton-mile is likely to be reached by designing for non-stop flights con-

siderably *under*, rather than over, 2,000 miles.[8] Thus the economic significance of the overland route to Asia is heavily underscored. Along this route, thanks to the war, adequate intermediate airports well within economical range are now available.

CHARACTERISTIC RELATION BETWEEN ECONOMY OF OPERATION AND LENGTH OF NON-STOP FLIGHT

APPROXIMATE GROSS WEIGHT, IN POUNDS: PLANE A, 25,000; PLANE B, 65,000; PLANE C, 150,000.



The overland airway to Asia is beyond the Aleutian bad weather belt.

The Aleutian Islands are notorious for their bad weather. But the overland route we are discussing goes nowhere near the Aleutians. At its nearest point it lies fully 900 miles north of the Islands, in an entirely different climatic belt.

Fairbanks, the principal Alaskan airport on the route, is sheltered from Aleutian weather by a mountain range which includes the high-

[8] Edward Warner in an extended analysis of long-range operations under specified conditions has concluded that "the practically desirable distance between stops where economy is a factor of major importance would appear to range from 700 to 1,250 miles." By reducing fuel reserve to one half the amount initially assumed, he suggests that a 35 per cent increase in this economic range may be possible. "Postwar Transport Aircraft," (31st Wilbur Wright Memorial Lecture, delivered before the Royal Aeronautical Society in London, May 1943), *Aeronautical Engineering Review* (October 1943), pp. 41-46. This economic range can also be extended if a plane can be operated safely with a maximum allowable *initial* gross weight substantially in excess of the permissible landing gross weight.

est mountain on the continent, Mount McKinley. Most of the airway is far from the coast, along an inland course where fogs are rare.

Subarctic areas present less dangerous flying hazards than are sometimes found in other latitudes. In high latitudes winds at flying levels are generally moderate.[9] Storm clouds which often tower up over 35,000 feet in the tropics are not likely to reach half that altitude in northern regions. Cold polar air is relatively stable. Winter temperatures at Fairbanks, Alaska, are no lower than at, say, Billings, Montana. In fact, with regard to flying weather, the overland airway to Asia is certainly no more difficult than the transcontinental airway between Chicago and Seattle, which has been flown on regular day and night schedules, winter and summer for years. Perhaps it is actually better.

Many months of intensive wartime operations throughout this area have taught us much about flying conditions along the Alcan Highway and beyond. Before hostilities in the Pacific are over, we shall have learned much more. This legacy of accumulated experience and of airway installations bequeathed by the war will help finally to remove the mirage behind which this northland has been hidden so long.[10]

What is true for San Francisco with regard to the route to Asia is even more true for the rest of the United States. Chicago, for example, is 1,500 miles nearer Batavia by the overland route than by way of California and Hawaii.

Alaska is the logical gateway to North America from Asia for

[9] The technical explanation is that a difference in atmospheric pressure which will produce a gale near the equator only causes a moderate breeze at these higher latitudes. Upper air winds such as are encountered not infrequently during the typhoon season on certain sectors of the transpacific airway rarely, if ever, occur along the overland airway to Asia.

[10] Stefansson has compared this mirage to the myth of "The Great American Desert" which for 40 years handicapped the development of what is today one of the world's great granaries—the Mississippi Valley

Alaska and the Yukon Territory occupy a position on the North American continent closely corresponding to that of Norway, Sweden, Finland, and Denmark on the European continent. The two territories are almost twice as big, but contain only half of 1 per cent of the population of Scandinavia. The weather has much in common. Of all the great quarters of the continent the Northwest has been explored and settled most recently, and the process is nowhere complete. In terms of potential development, the region is still young.

It is important to recognize the tremendous basic difference between the Antarctic and the Arctic The former consists of a high ice-capped continent of immense size encircled by a great ring of water, the latter is very much smaller and is a deep-sea basin surrounded primarily by low land As a result, winters in many parts of Alaska and the Yukon are not as severe as that at many inland points in our own Northwest On the west coast as far north as Sitka, winters are often as mild as at Atlantic City. See Benjamin H Kizer, *The U. S.-Canadian Northwest* (1943); also Vilhjalmur Stefansson's classic, *The Northward Course of Empire* (1922).

air traffic originating practically as far south as Darwin, Australia, and as far inland on the Asiatic continent as the Burma India border. Indeed, Calcutta, India, is the half way point from Chicago around the Principal Hemisphere, either westbound by airway via Edmonton, Fairbanks, Peiping, and Chungking; or eastbound through the Labrador aerial gateway via London, Warsaw, and the Khyber Pass

Labrador is our primary aerial gateway to Greater Europe, Africa, and Western Asia.

Here again, the scarcely creditable fact is once more emphasized that the logical air route to many southerly points is first northward

DALLAS, TEXAS, TO VICTORIA FALLS, SOUTHERN RHODESIA
(Distance in statute miles)

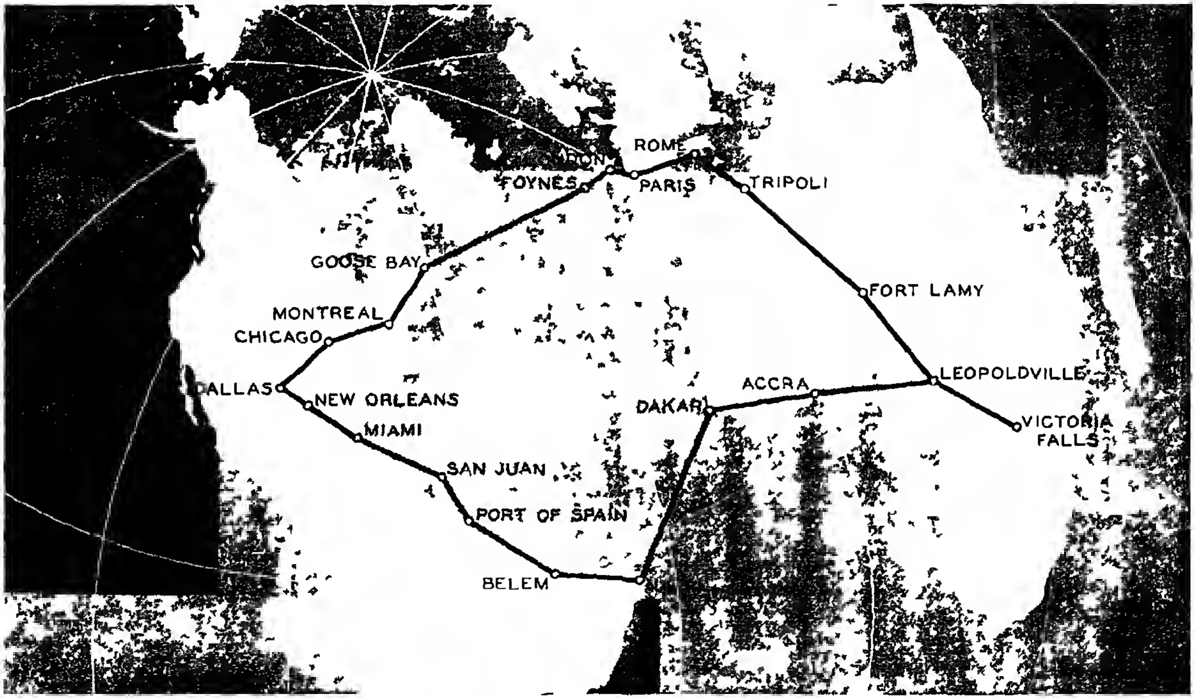
Via Labrador Gateway			Via South America		
Airport	Intermediate	Cumulative	Airport	Intermediate	Cumulative
Dallas	—	—	Dallas	—	—
Chicago	820	820	New Orleans	450	450
Montreal, Canada	755	1,575	Miami	680	1,130
Goose Bay, Labrador	790	2,365	San Juan, Puerto Rico	1,035	2,165
Foynes, Ireland	2,065*	4,430	Port of Spain, Trinidad	620	2,785
London, England	390	4,820	Belem, Brazil	1,230	4,015
Paris, France	220	5,040	Natal, Brazil	970	4,985
Rome, Italy	680	5,720			
Tripoli, Libya	625	6,445	Dakar, French West Africa	1,870*	6,855
Fort Lamy, French Equatorial Africa	1,435	7,880	Accra, Gold Coast	1,300	8,155
Leopoldville, Belgian Congo	1,140	9,020	Leopoldville, Belgian Congo	1,265	9,420
Victoria Falls	1,180	10,200	Victoria Falls	1,180	10,600

* The longest over-water flight via Labrador is 2,065 miles, via South America 1,870 The average length of flight via Labrador is 927 miles, via South America 1,060 (This applies, of course, to the particular choice of airports shown)

Across the South Atlantic the heaviest air travel undoubtedly will be via Dakar and Natal (as shown above), as that is on the main line between Europe and South America Airway facilities at these points will be a part of the important legacy of war See map of Air Transport Command routes, p 40

It is possible, however, by landing at the tiny island of Ascension, to break the South Atlantic over-ocean flight into two stages of 1,450 and 1,360 miles each This shortens the flight between Natal and Accra by about 360 miles See John Gunther, "Ascension Island —Mighty Midget," *Reader's Digest*, Vol 44, (January 1944), p 33

Airways to Africa via Europe or South America



1 » ul al equ distant projection centered on W ash ngton, D C

Take the case of a business man who lives, say, in Dallas, Texas, and plans a flying vacation to Victoria Falls in South Africa. Again, a strictly great circle course has no practical significance for him, as it would mean a non-stop flight of some 6,700 miles over open ocean.

The obvious alternative course suggested by a Mercator world map, would be via New Orleans, Miami, Trinidad, along the Brazilian coast to Natal, across the South Atlantic to the western bulge of Africa, and thence southward to the Falls. Actually, however, *the shorter airway is via Labrador and Europe*, as will be seen in the accompanying table and map.[11]

The first 5,000 miles takes the traveler on the southern route as far as Natal, Brazil. Via Labrador our passenger already would have passed through London and be about to land in Paris.

A wide choice of routes through Europe will still bring him to Victoria Falls in less air miles than via South America. The same is true if his destination is Johannesburg, or Durban, or most other points in Africa. A Mediterranean detour to visit Athens, Cairo, and Khartoum en route to South Africa adds only an hour or two additional flight time. If he desires, he may plan stopovers at any of these points.

It is possible, of course, to plot a path across the South Atlantic from Brazil 1,450 miles to the tiny island of Ascension; thence 810 miles to St. Helena (where Napoleon was exiled) and on some 2,100 miles to Victoria Falls, a saving of about 1,300 miles for the total route. An alternative course on the northern route also can be laid out from Labrador via the Azores and Canary Islands, eliminating

[11] In the following discussion we have shown the northern route via the new international airport at Goose Bay, Labrador, rather than the earlier installation at Gander or Botwood, Newfoundland, because weather conditions are so much better at the former.

The amazing story of the development of Goose Airport in Labrador cannot be fully told until after the war. Over 20 million dollars is said to have been spent on improving it, of which the United States is alleged to have contributed 7 millions and the Canadian and British governments the remainder. There are miles of roads, great long concrete runways; the contractors cut about 10 million feet of lumber in building the base alone. It is said to be one of the best natural air bases on the continent. As this it written, the Royal Canadian Air Force, the Royal Air Force Transport Command, and the Air Transport Command of the United States Army Air Forces use it jointly.

Labrador, broadly speaking, is a vast level plateau, except for mountain ranges which flank the seaboard and help shield the airport from the coastal weather. By a decision of the Privy Council of England in 1927, all the land of the eastern seaboard drained by rivers flowing into the Atlantic was made a part of Newfoundland. Newfoundland voluntarily relinquished its status as a self-governing dominion in 1933, due to financial difficulties, to become a British Crown Colony.

Europe altogether and similarly eliminating about 1,300 miles to South Africa.[12]

Available as such island air routes are for occasional use, to justify them for regular daily commercial operation implies a volume of traffic between South Africa and the Americas greater than seems reasonable to expect for the immediate future. Rather than establish, operate, and maintain airways across great stretches of open water, it is economically more desirable, where possible, to chart a course through regions where the prospect of serving intermediate traffic is better. South Africans, for instance, will probably have business or personal reasons, or both, for preferring to visit Europe and Britain en route to America, rather than Ascension, St. Helena, or the Canary Islands. Airways expenses thus will be distributed over a greater density of travel, with resulting lowered unit costs. As to the traffic-producing potential of Europe compared with the east coast of South America north of Natal, the former is astronomically greater.

The same principle applies with respect to travel to India, to the Middle East, industrial Russia, and to all of Greater Europe. The airway traveler from most of North America is not only nearer by way of the Labrador-Newfoundland gateway to every city within this immense arc, but is likely to find at his disposal the newest and largest aircraft, a far higher frequency and variety of services, the greatest luxury, the fastest schedules, and many more intermediate cities of interest than by any alternative route.

The world's most important international airway is also the most difficult.

Although destined to handle a greater volume of international air traffic than probably any other inter-regional airway in the world, the Labrador-North Atlantic route suffers from two very serious handicaps: one is the length of the non-stop flight imposed between the North American and European continents; the other is the weather, particularly icing and adverse winds.

There are, to be sure, the intermediate islands of Greenland and Iceland, the latter of which lies 650 miles to the north of the direct course. Via these points the maximum non-stop distance is about 800 miles. Eliminating Greenland except as an emergency stop, the longest flight would be approximately 1,500 miles. Unhappily, weather hazards at Iceland, and more particularly at Greenland, render the de-

[12] See map of Air Transport Command routes, p. 40.

pendable scheduling of a large volume of operations via these islands a doubtful matter during several months of the year.

Perhaps ultimately the development of blind landing devices and other navigational aids will render air transportation entirely indifferent to weather. If so, it will be the first form of transportation ever to attain such complete independence. There is, morever, the question of the comfort of passengers to be considered, particularly on overnight trips, coming down repeatedly into stormy surface weather for intermediate landings.[13]

South, 1,150 miles below the direct eastbound route out of Goose Bay, and separated from it by some 1,800 miles of open ocean, lie the Azores. Weather conditions in this area are far better in general than in the vicinity of Iceland.

The Azores, however, lie so far off course that their use involves a major penalty in increased mileage. The detour via Horta adds 945 miles, for example, to the minimum airway mileage between London and Chicago. If an entirely different solution is sought via Bermuda, not only are 200 miles more added to the swollen total of the Horta detour, but the longest non-stop flight imposed is as great as, or greater than, via any alternative route. (See map page 40.)

This, then, is the challenge which the key route of the world presents to airline operators and aircraft manufacturers alike. Larger transport aircraft capable of *economic over-weather non-stop flight* between Labrador and the British Isles are badly needed. In the state of the art which will be reached by war's end, such planes can be built.

Whatever added cost may be imposed by the length of the long non-stop flight can either be absorbed in operations elsewhere on the world network, where operating conditions are less rigorous and traffic density is similarly high; or a slightly higher rate per mile may have to be charged for the North Atlantic crossing.[14]

[13] In one sense, of course, air transportation has already largely attained independence of weather: that is, by flying over it. The *intermediate* landing is the major problem remaining.

If the time should ever come when intermediate landings present no problem, it is of interest to note that a great circle course connecting the capitals of the United States and the U.S.S.R. passes directly through Goose Bay (Labrador), the tip of Greenland, the capital of Iceland (Reykjavik), Trondheim (Norway), and the capital of Finland (Helsinki).

[14] A proposal for shortening the length of flight stages otherwise required, by using huge specially constructed floating landing strips, has long been urged by Edward R. Armstrong, designer of "The Armstrong Seadrome." The general plan provides for a long level platform perhaps 75 feet above the surface of the ocean supported by an openwork steel bridge-type construction and resting on "buoyancy" columns submerged to a maximum depth of perhaps 175 feet.

Our entire southern area is a "gateway" for air routes to Middle and South America.

Not only cities along our southern border but, equally, communities hundreds of miles inland are potential aerial ports of entry to and from Latin America. Indeed, the third approach to this continent is not a gateway at all, but a great "sluiceway" from the Atlantic side of the continent to the Pacific. Geography for once has been lavish with its island stepping stones and overland bridge, which provide intermediate landing points on air routes between the Americas.

As if to compound the airplane's advantage, surface transportation is seriously handicapped in the majority of Latin American countries. For four hundred years the twin forbidding barriers of the immense jungles of the Amazon basin and the Andean mountain chain running from Mexico to the tip of South America have dictated the pattern of surface transportation to the south of us. Ground communication for the most part has hugged the coast, while much of the hinterland remained relatively undeveloped and inaccessible.

From Lima, capital of Peru, to Iquitos, for example, in the northeast corner of the country on the upper waters of the Amazon, the normal mode of travel before the war was by boat through the Panama Canal, around South America and back up the Amazon River—a journey of many thousand miles involving 30 days or more. Overland, the only alternative until very recently was a three weeks' trip over the difficult Pichis trail. A road has now been pushed across the Andes and through jungle swamps to Pucallpa, on the Ucayali River, whence the journey by launch to Iquitos can be completed in something less than a week. By air, the distance is only 735 miles. Modern transport aircraft can negotiate the trip in three to four hours.[15]

Tests have shown, it is claimed, that such a structure would ride out the worst of storms at sea without any perceptible roll, pitch, or heave. It is estimated that such a runway, say one mile long, would weigh close to 100,000 tons, might cost 15 to 20 million dollars. Pennsylvania-Central Airlines Corporation, a domestic air carrier, has incorporated the seadrome idea in its application (Aug. 9, 1943) to the Civil Aeronautics Board for a certificate to engage in transatlantic service.

A detailed discussion of the merits of this intriguing scheme is out of place here. It may be said, however, that *if* it were both technically and economically feasible to provide and operate dependably off of an adequate floating airport anchored midway between Labrador and the British Isles, it would contribute to the solution of one of air transport's major postwar problems. The proposal, however, has not met with wide-spread support. Its merit tends to diminish with the evolution of aircraft design.

[15] J. Parker Van Zandt, "The Air Transport Market in Latin America," *Journal of the American Society of Mechanical Engineers*, Vol. 65 (September 1943), p. 649.

Air routes to the South are not yet sufficiently weaned from surface geography.

The age-old obstacles to surface transportation have had a restraining effect on the development of air routes in South America. Broadly speaking, air transportation in this area has not yet capitalized on the inherent flexibility of modern flight.

There are, of course, technical, economic, and political reasons to explain this historical patterning after surface communications: the early range of planes was severely restricted; traffic was light; airports, airways, and other facilities were hard to establish or to maintain except along well-traveled surface lanes. The war has altered most of this. As a consequence, extensive changes may be foreseen in the pattern of air service to the South.

Present air travel between the capitals of many South American countries is almost as circuitous as the old surface routes. The direct line, for example, between Lima, Peru, and Caracas (La Guaira), Venezuela, (passing over Iquitos en route) is 1,725 miles. Technologically, ten-hour service between the two capitals is now entirely feasible. The present airline connections, however, normally require three days and the route followed is almost a thousand miles longer than the direct course.

Roundabout air routes have contributed to higher charges.

Roundabout routes, combined with existing fares, result in passenger rates which, when reviewed against the mileage of the shortest possible route, appear abnormally high in many cases. The following table shows the equivalent fares for four such "cut-offs" across the Amazon basin, as well as on four other routes.

Route	Published One-Way Passenger-Fare January 1944 (U.S. dollars)	Shortest Direct Distance (Statute miles)	Equivalent Rate per Passenger-Mile (U.S. cents)
Lima (Peru)-La Guaira (Venezuela)	271	1,700[16]	15.9
Lima (Peru)-Bogota (Colombia)	152	1,160[16]	13.1
Bogota-Rio de Janeiro (Brazil)	349	2,860[16]	12.2
Bogota-La Guaira	119	650	18.3
Miami-Bogota	183	1,520	12.0
Miami-Rio de Janeiro	425	4,210[16]	10.1
Buenos Aires (Argentina)-Rio de Janeiro	110	1,25[illegible]	8.8
Buenos Aires-Santiago (Chile)	60	710	8.5

[16] These routes traverse some part of the Amazon Basin.

The rates quoted are straight one-way charges and do not reflect round-trip and other discounts. Compared on an identical basis with what a traveler on United States domestic airlines pays, the cost is very much higher. To select two or three United States domestic routes for comparison, at random: between Seattle and San Francisco, on the west coast, the current published one-way passenger fare per mile of the shortest direct route is 5.0 cents; between New York and San Francisco it is 5.4 cents and for the 725-mile flight between New York and Chicago it is 5.4 cents.[17]

The war has greatly accelerated the growth of air travel throughout Middle and South America. By the end of hostilities it will probably be several times what it was at the beginning of 1941. This greatly increased volume of air traffic between and within the Americas, and the resulting much higher frequencies of service, eventually will lead to substantial reductions in the present scale of charges.

Provided regulatory and political obstacles do not intervene, this area offers a promising field for the services which air transport can render after the war. It is important to remember, however, that much of Latin America is relatively young, in an economic sense. This very economic youthfulness, as the percentage charts of Chapter II so heavily underscore, imposes a limitation on the volume of transportation which can be expected to develop in the near future whether by surface or by air.[18]

Many military airways have little potential commercial importance.

In the spring of 1942 when Rommel's Afrika Korps was knocking at the gates of El Alamein, air routes through the Caribbean assumed

[17] See also William A. M. Burden, *The Struggle for Airways in Latin America* (1943), p. 123: "Pan American's and Panagra's 1942 trunk route rates of 10 to 11 cents per mile were approximately double the United States domestic rates. . . . Pan American's international fares, which are set in United States currency, have not been reduced very much in the last seven or eight years. In this period, however, there has been a drastic depreciation in Latin American currencies so that the present rates of 9 to 10 cents per mile (after the March 1943 reduction) constitute—in normal times—an obstacle to widespread use of the trunk line services by Latin Americans, particularly for long journeys such as to the United States."

[18] See, for example, Eugene Van Cleef, "Obstacles to South American Trade Growth," *Barron's National Business and Financial Weekly*, Feb. 7, 1944, p. 6. Van Cleef estimates that all but a negligible part of the purchasing power of the South American Continent is in the hands of about 28 millions, and that on the basis of our 1938 share of it "the average market available to us [on the South American Continent] approximates the population of Ohio. . . . Trade is there, but for this nation, as a whole, extensive business is still primarily potential. . . . We must view [it] as an opportunity to be developed during the next half century or more."

a very special significance. They were a vital link in the United Nations' trans-African supply line. Even after the elimination of Axis troops from North Africa this Caribbean-Natal-Africa detour has preserved its military importance. It will continue to do so as long as Europe remains in enemy hands.

Air Transport Command Routes of the United States Army Air Forces in the Principal Hemisphere

When peace returns, however, both this route as well as other airlines of vital military value, such as across the South Pacific, will lose much of their current importance. Then, economic rather than temporary strategic factors will control.

Global routes in operation by the Air Transport Command of the United States Army Air Forces in January 1944 are shown on page

40.[19] In two short years this Command has built up the greatest air transport service in all history. Total absence of routes over so much of the European-Asiatic continent—the largest land mass in the world—suggests the extent to which current exigencies of war have diverted these airways from normal geographic and economic channels. The chart also emphasizes, however, the legacy of incalculable value which global warfare will leave to world air transport.

Certainly many bases built under stress of military necessity will be of little or no use for postwar commerce. Already bases and air routes are being abandoned as military fronts move into new areas. But investments at Goose Bay, Labrador; along the Alcan Highway to Alaska and beyond; and many other airways aids along important routes of the future can contribute immeasurably to the rapid development of world air transport.

So also will advancements in the science and art of aeronautics. In operating experience alone, for example, the Army Air Forces prior to January 1, 1944 had made over 20,000 transocean flights.

The airplane is the architect of a changing world.

Global air transportation is redressing frontiers and shrinking nations to neighborhoods. Two of the factors which will dominate the evolution of this postwar pattern are geography and the economics of commercial long-range flight. The third is politics. If we assume for the moment that political obstacles ultimately can be surmounted, then the basic pattern of international trunk routes should develop along the lines shown.

In the Pacific area, nature has generously provided a bridge along the shortest course to Asia. On the Atlantic side, the separation of the continents creates a more difficult problem.

Between Europe and the major centers of South America the great circle course hugs the coastlines of West Africa and South America where the two continental "bulges" reach out toward each other across the South Atlantic. In the North Atlantic the closest continental approach is between the British Isles and Labrador-Newfoundland.

This is the basic pattern that is likely to predominate until the art of flight develops to where non-stop schedules of, say, 3,500 miles (such as New York to London direct) can be operated with as good

[19] From *Report of the Commanding General of the Army Air Forces to the Secretary of War*, Jan. 3, 1944. The only Air Transport Command operations not shown on this map of the Principal Hemisphere are the South Pacific routes.

economy, per passenger or per revenue-pound, as the same service when flown with intermediate stops every 1,000 to 2,000 miles.

No nation has a "corner" on international air routes.

A possession of the United States (Alaska), a dependency of a British Crown Colony (Labrador), and Soviet Eastern Siberia, are perhaps the three most "strategic" territories lying athwart the network of world airways. They all can be by-passed, however, if inept politics makes it necessary.

No nation is endowed with a natural monopoly of international airways. Alternative routes exist, somewhat less desirable perhaps but none the less feasible, between all the major trade regions of the world.

Granted it is simpler to fly from the United States to Asia by way of Canada and Soviet Siberia; it is also possible, and actually shorter, to go via the northwest coast of Alaska, the Aleutians, and the islands of Japan. In addition, there is the present longer detour via the islands of the mid-Pacific.

In the Atlantic area, en route to Europe, via Maine to the Azores (a Portuguese possession), the non-stop flight is no longer and perhaps less difficult than that imposed by the more direct course via Labrador and Eire. Canada can easily by-pass the United States on services to South America by flying via Bermuda; Brazilian ports are not essential for traffic between North America and Africa. (See the airway maps on pages 23, 26, 33, and 40.)

The truth is, the economic range of modern transport aircraft has eliminated the last "irreplaceable" airport in the entire Principal Hemisphere. The mischievous notion that nations are in a position to thwart each other by a "dog-in-the-manger" attitude toward strategic airport sites is another harmful product of the distorted Mercator image in which most people view their world.

Geography is still a controlling factor.

The geography we have been discussing is not new. It has been here a long time. The Labrador re-discovered two years ago by the United States, Britain, and Canada when they invested a small fortune at Goose Bay was there long before the first successful flight.

What is new is the changed significance of geography. For cen-

turies surface-bound mankind, like an ant on a rug, has been limited in his outlook and cramped in his progress. The pattern eluded him.

Now aircraft have enormously extended his range and expanded his vision. But the plane, in its turn, is handicapped by geography; only the scale and nature of the control has changed. The hard facts of geography are still the bedrock on which to build soundly for the Air Age.

We have seen what some of these geographical facts are. There remain many complex political and economic aspects still to be considered, on which the future of world air transport no less depends. What, for example, are the military implications in world air transport and what is its relation to civil aviation as a whole? How shall international air routes be owned, operated, and regulated? What is the role of aviation in the preservation of peace? These and related problems will be considered in succeeding publications in this series on "America Faces the Air Age."

World air transport holds out a prospect more alluring in terms of human welfare than any before in history. Yet the difficulties in the way of realizing its rich promise are admittedly great. As a first step, we need to understand as thoroughly as possible the basic elements of the problem. If this introductory volume has contributed to a better understanding of some of these underlying elements, it has achieved its object.

APPENDIX A

A NEW WAY TO FIND FLIGHT PATH AND DISTANCE WITHOUT COMPUTATION

A word about maps

Maps are a tricky subject for most of us. "The beginning of wisdom in cartography is the realization that all maps *without exception* are distorted."[1] It follows that the problem of finding the shortest path and distance between two points on an admittedly distorted chart is sometimes a very involved process.

Mathematical formulas and tables for calculating the great circle course and distance between points whose latitude and longitude are known can be found in standard works such as Bowditch.[2] These mathematical solutions of the spherical triangle, however, are not in general suitable for the average person's use. In addition, they require an accurate knowledge of the latitude and longitude of both points, which is not always readily available.

The gnomonic projection permits the determination of the true *path* of a great circle simply by drawing a straight line on the map between the two points in question. With respect to shape, area and scale, however, this projection exhibits fantastic distortions. Hence the determination of distance on such a map is not easy. In general it involves calculation or the use of a special nomograph.

Most map projections for large areas belong to one or the other of two great classes, the conical (including the cylindrical) and the azimuthal (or zenithal) projection. The gnomonic is one of this latter class. Azimuth is just another word for direction. Any projection which preserves the true direction of all lines radiating from the center of the map belongs to the family of azimuthal projections.

No projection can be devised which will give *both* direction and distances correct throughout the map. The azimuthal equidistant projection, however, will do so for one point at least—the center. This projection takes its name from two most important properties, namely that straight lines radiating from the center represent great circles in their true direction

[1] Great Circle Airways (North Polar Gnomonic Projection, drawn by R. E. Harrison), *Fortune*, (Suppl.) Vol. 27 (May 1943): "It is a melancholy reflection on the state of our geographical sophistication that it is still necessary to emphasize this simple fact [of distortion]."

[2] Nathaniel Bowditch, *American Practical Navigator*, U. S. Navy Department H. O. No. 9 (rev. ed. 1938). The standard cosine-haversine formula is given on p. 107.

(or azimuth) from it, and distances along these lines are uniform (although not necessarily correct) in scale This is the projection we have employed throughout this book to represent the Principal Hemisphere.

In addition to its property of showing true great circle direction and distance from the center of the projection, the azimuthal equidistant map represents a happy compromise between extremes of distortion found in most other maps. In this map the scale along the radii, or spokes, is maintained constant, while what stretching is inevitable in order to avoid splitting or "interrupting" the map, is progressively applied at right angles to the spokes.

By the time the horizon of a hemisphere is reached, the stretching along the rim results in an increased scale approximately 57 per cent $\left(\frac{\pi}{2}\right)$ greater than the scale at the center Stated the other way around, in the Principal Hemisphere map used throughout this book the scale at the center, and along lines radiating out from the center, is about one third (36 3 per cent) less than that along the outside rim.[3]

The maximum relative distortion in a hemisphere map drawn on other well-known types of projection is given in the following table:

MAXIMUM RELATIVE DISTORTION IN A HEMISPHERE MAP DRAWN ON DIFFERENT PROJECTIONS
(Ratio of small unit at horizon to similar unit at center of map)

Projection	Length		Area
	At right angles to horizon (Along meridian)	Parallel to horizon	
Mercator	(Maximum distortion parallel to axis of projection becomes infinitely large in a full hemisphere)		
Gnomonic	(Maximum distortion becomes infinitely large in a full hemisphere)		
Orthographic (within approximately 400 miles of horizon)	Over 10 0	1 0	Over 10 0
Stereographic	2 0	2 0	4 0
Azimuthal Equal Area	0 708	1 414	1 0
Azimuthal Equidistant	1 0	1 57	1 57

As the above comparison discloses, not a single projection is free from some variation in scale in at least one direction. Nor does any show as

[3] One way to make mental correction for the variation in scale when using this map is to imagine it drawn on the inside of a large hemispherical dome, such as the "outside-in" globe constructed by The Museum of Modern Art, New York City, for their recent exhibit "Sky-Roads", or it may be thought of as on the inside of a large bowl, so that what you see is somewhat foreshortened with respect to the scale along the edge

Another way is to imagine it printed on a flat rubber membrane which can be clamped firmly around the horizon and then blown up into the shape of half a ball In this expanded globular shape everything would be restored approximately to correct size, shape, distance, and relative location See footnote, Chap. III, p. 23.

small a variation as the azimuthal equidistant for an area as large as a hemisphere, with the exception of the azimuthal equal area projection. The latter, however, does not preserve true shape as well as the azimuthal equidistant.

Since maps introduce such complications, we might be forgiven the impulse to scrap them all and revert to a globe. After all, a globe is the one place where all "global" relations are shown as they actually exist. But a globe itself has shortcomings. It is not really a map, but a scale model of the earth and as such, of course, cannot be reproduced in a book.

Great skill is required to construct a truly accurate globe. If it is big enough to provide a scale on which distances can be measured accurately, it becomes bulky, expensive and unwieldy.[4] Contrary to the general impression, it is not possible to see half of a globe all at once. (Try it!) The larger the globe, the more restricted is the area which can be studied at any one time.

There remains still another alternative for finding true distances: Tables can be computed showing the great circle distance between various pairs of points throughout the world. The practical difficulty, of course, arises in the selection of points. A perfectly fantastic number of calculations would be necessary to cover all combinations of possible interest.[5]

Determining great circle courses and distance without computation.

A number of methods for solving the spherical triangle graphically, such as the Byerly Navigation Device, have been proposed from time to time. These are of interest particularly to the professional navigator.[6]

Mr. O. M. Miller, of the American Geographical Society, has recently devised for the United States Department of State an ingenious diagram for

[4] See the excellent little pamphlet distributed by the Consolidated Vultee Aircraft Corporation, on *Maps—and How to Understand Them* (1943). A number of globe manufacturers now include a measuring tape, or a great circle and distance-finder device with their models.

[5] Airline distances between 45 world cities, for example, are shown on the back of the Rand McNally Polar Map of the World. The National Geographic Society frequently includes such tables for selected cities, with their maps. *Fortune* maps generally show great-circle distances for particular routes. The Civil Aeronautics Board has prepared two booklets showing airport-to-airport mileages over authorized routes for American-flag air carriers. Other limited tabulations are available. Such is the perversity of figures, however, that more often than not, the particular combination wanted is just the one missing.

[6] The Byerly Navigation Device consists essentially of a transparent overlay superimposed on a gnomonic projection. The two points between which it is desired to determine the great-circle distance are plotted on the overlay, which is then rotated about the point of tangency until the points so plotted lie along a meridian, when the great-circle distance may be determined (in nautical miles) as the difference of latitude between them. A polar gnomonic projection is necessary if one of the points lies in the higher latitudes.

plotting great circle routes, in conjunction with a special cylindrical projection, also prepared by Mr. Miller for the Department. The professional cartographer, equipped with a light table and provided with this special map and chart can ascertain great circle routes and the shortest approximate distance between any two points on the earth's surface conveniently and without computation. The layman, however, is not in general so well equipped; also the diagram's complicated pattern of curves and nodes is likely to prove somewhat bewildering to him.

What the average reader with a normal interest in global affairs would like to have is something still more simple and understandable, requiring no special apparatus or prepared projections. Some convenient "gadget" he can use with maps supplied him by his National Geographic Society, for example, or for sale at book stores, whereby he can identify and determine quickly and accurately the shortest distance between whatever combination of points in which he may be momentarily interested. The following paragraphs describe such a device developed by the author:

The new Flight Path and Distance Finder.

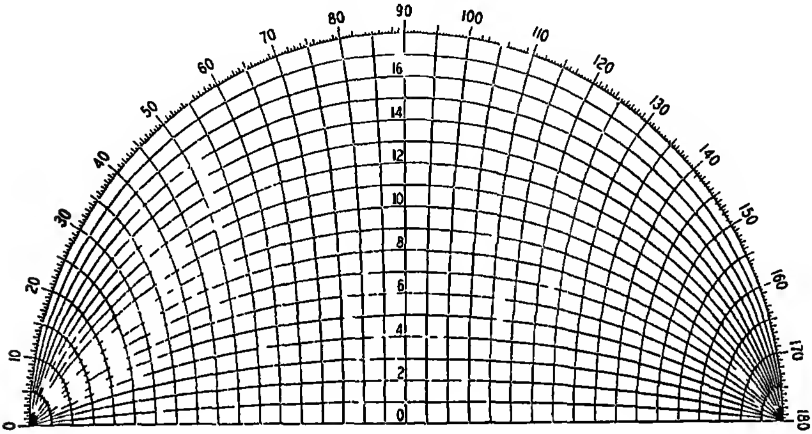
Take any circular hemisphere map drawn on an azimuthal projection and place over half of it a semicircular transparent sheet of non-shrinkable plastic material.[7] Pivot this overlay at the center of the map so that it may be rotated freely about the center point. Trace on the transparent sheet an outline of the semicircle which corresponds to the scale of the map; that is, a straight line through the central pivot point, which is the diameter of the semicircle, and a semicircular outer edge overlying the horizon of the map.

These two lines represent the projections on the overlay of the two great circles which bisect the globe vertically and horizontally. There are, of course, any number of oblique great circles between these two which will divide the globe in half, ranging all the way from the vertical to the horizontal. It only remains to draw a family of such great circles on the transparent sheet, as shown in the illustration on page 48.[8]

[7] The map of the Northern and Southern Hemispheres on the azimuthal equidistant projection published in April 1943 by the National Geographic Society is convenient for this purpose. The particular form of the device described here is only one of a number of possible alternative arrangements which are covered in a patent application pending. Another device dependent on a somewhat similar principle has been developed recently by Drs. William W. Flexner, Loren C. Petry and Oskar D. von Engeln of Cornell University. *Science News Letter*, Sept. 18, 1943.

[8] This can be done by the use of special nomographs such as those described by Richard Edes Harrison, "The Nomograph as an Instrument in Map Making," *Geographical Review*, Vol. 33, No. 4 (1943), pp. 655-57; or it may be computed from standard sources such as U. S. Navy Department, *Azimuth Tables*, H. O. No. 71 (15 ed. 1934). As a graphical aid in this connection, the U. S. Coast and Geodetic Survey has prepared an equatorial azimuthal equidistant projection at 1° intervals. (No. 3065).

By dividing the great circles into a uniform number of parts, say every 50 miles, or every degree, we are provided with a scale with which to measure distances along the great circles. In the overlay illustrated below the principal divisions are drawn every five degrees and a single scale along the horizon is arranged to serve for the entire family of great circles. It has been found that for a map of ten-inch radius, intermediate readings can be estimated consistently to within one tenth of a degree, equivalent to 6.9 statute miles.



For convenience in marking the route on the map along any great circle lying beneath the grid on the overlay, perforations are made in the transparent sheet at appropriate intervals through which a pencil point may be inserted.

Use and accuracy of the Flight Path and Distance Finder.

That is all there is to the device—a pin and a piece of plastic. Its use is equally simple: merely rotate the overlay until the pair of points in which you are interested appears under one of the great circles, or is equally spaced between two such adjacent curves. Read the scale opposite each point. Subtract the smaller reading from the larger. The difference is the minimum distance you are seeking; and the overlying curve which connects the two points is the great circle route.

To anyone who has occasion frequently to refer to great circle routes, the ease and rapidity of this solution and its surprisingly high accuracy are a continual delight. Ten pairs of points, for example, were chosen more or less at random and measured in a few minutes on the National Geographic hemisphere maps referred to above. The measurements so

obtained when compared with great circle distances painstakingly calculated by mathematical formulas, gave the following results in statute miles:

Accuracy of Flight Path and Distance Finder
(Great Circle of Shortest Distance)

Between	Mathematical Solution	Graphical Solution	Difference	*Per Cent of Error*
Chicago–Calcutta	7,980	7,980	0	*0*
New York–Moscow	4,665	4,630	−35	*0.75*
Rio de Janeiro–Capetown	3,770	3,740	−30	*0.80*
Moscow–Tokyo	4,650	4,665	+15	*0.32*
Mexico City–Montreal	2,315	2,318	+3	*0.13*
Chungking–Cairo	4,430	4,430	0	*0*
Newfoundland Airport–Colon	3,100	3,075	−25	*0.81*
Chicago–Rio de Janeiro	5,310	5,351	+41	*0.77*
New York–Khartoum	6,345	6,380	+35	*0.55*
New York–Berlin	3,965	3,962	−3	*0.08*
Average discrepancy			±18.7	*±0.40*

The maximum single error was approximately four fifths of one per cent. The average individual error was two fifths of one per cent. This, in spite of the normal shrinking or stretching to which a paper map is always subject.

Advantage of use with a map of the Principal Hemisphere.

It may often occur, when using maps of the Northern and Southern hemispheres, or Eastern and Western hemispheres, that both of the points between which the great circle course and distance is desired will not be in the same hemisphere. This is not serious, but it does involve a slight additional complication which it is desirable to avoid if possible in the interest of utmost simplicity.

Here one of the advantages appears of employing a map which represents such an overwhelming proportion of "all the world that matters."[9] With 94 per cent of all the people on earth concentrated in the Principal Hemisphere, with 98 per cent of the world's industry carried on there, with practically every air route of commercial importance represented there, it rarely becomes necessary to go outside. Should such a contingency arise, however, it is easily resolved.[10]

[9] See, for example, maps on pages 10, 23, and 40, and on inside covers.

[10] Briefly, it involves the use of two similar overlays, one for each hemisphere. To measure the shortest path between a point in one hemisphere and a point in the other, put the same great circle on each overlay through one of the points *and* an identical point on the horizon. Then the sum of the two distances to the horizon is the great circle distance desired. Dr. Flexner and associates in their proposal have met

Thus in this device, particularly when used with the Principal Hemisphere map, we have a simple, accurate and rapid means of determining without computation the shortest distance between any two points and of visually identifying, or marking on the map, the great circle route between them. Further, it will be found that frequent reference to the Flight Path and Distance Finder is of great assistance in keeping clearly in mind the nature of the distortions unavoidably present in any map projection employed.

It is the author's hope that this brief description of a device which has proved so useful to him will be of benefit to others whose interest in global matters and great circle courses has been stimulated by recent world events.

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this problem by permanently mounting two hemisphere maps back to back, and then by an ingenious method, locating the antipode of one of the points in the opposite hemisphere.

APPENDIX B

WORLD ECONOMICS ON A REGIONAL BASIS

In Chapter II, pages 11-18, the economic characteristics of eight major trade regions were summarized in a series of "pie" charts and tables, showing the contribution of each region in proportion to the respective world totals.

The following pages give the amounts represented by those percentages. The data are also shown in greater detail, by countries, or other subdivisions, so that they can be grouped to form alternative regional arrangements if desired. Information for these tables has been assembled from such widespread and varied authorities that only the principal sources are listed.

World-wide data on a reliable comparative basis are not always available, unfortunately, even on relatively simple aspects. Nobody knows, for example, the amount of productive land in the world. There has been no official estimate of population in Tangier for over eighteen years; the last census in Danzig was in 1929. With regard to more complex economic matters such as comparative real income, only the most qualitative estimates are possible.

The most reliable and comprehensive figures available have been used in the preparation of the tables which follow. The eight primary regions into which in each case the data are assembled, are described on page 9 and shown on the map on page 10, Chapter II. The subdivisions of the first table on page 52, showing world distribution of land and population, also indicate the composition of these eight regions in considerable detail.

Distribution of people and land.

Population data shown in the accompanying table were generously made available by the Division of Geography and Cartography of the Department of State, where they were compiled chiefly from data furnished or approved by the Office of Population Research, Princeton University. The census or estimate dates vary from 1920 to 1942 and for the most part are for years later than 1930. Whenever possible the number of cities refers to metropolitan or urban areas; for example, Greater London includes 10 cities of 100,000 or more.

Data on total land area were also provided by the Department of State. "Areas" relate to land free of perpetual ice caps and wholly exclude oceans and arms of the sea. The sources for area data were official national publications, wherever available; otherwise, the ***Statesman's Year-Book, 1942*** and the ***Statistical Year Book of the League of Nations, 1940-41.***

World Distribution of Land Area and Population[a]

Region	Land Area (In thousands of square miles)		Population (In thousands)	Cities of 100,000 or more	
	Total	Cultivated		Number	Population (In thousands)
GREATER EUROPE [b]					
British Isles	121	26	49,185	47	20,873
Continental Europe	1,925	660	338,356	174	61,263
Mediterranean Africa	2,135	102	33,713	11	3,555
Mediterranean Asia	403	53	21,408	6	1,541
Total	4,584	841	442,662	238	87,232
NORTH AMERICA					
Canada and Newfoundland[c]	3,664	91	11,731	8	2,605
United States	2,977	623	131,669	108	60,418
Alaska	571	1	73	—	—
Hawaii	6	1	423	1	181
Total	7,218	716	143,896	117	63,204
U S S R.	8,176	923	170,467	82	27,436
ASIA, EXCLUDING MEDITERRANEAN					
Japan proper	148	23	73,114	45	21,346
China (including Manchuria, and dependencies)	4,566	310	481,240	46	20,465
India (including French and Portuguese India)	1,578	439	389,877	51	14,969
Others	3,943	212	210,829	39	10,013
Total	10,235	984	1,155,060	181	66,793
AFRICA, EXCLUDING MEDITERRANEAN	9,418	184	114,313	9	2,178
MIDDLE AMERICA					
Mexico	758	28	19,452	4	1,998
Central America	223	19	8,932	3	394
West Indies	91	17	12,790	6	1,249
North Coast of South America[d]	962	10	12,695	5	863
Total	2,034	74	53,869	18	4,504
SOUTH AMERICA, EXCLUDING NORTH COAST					
Brazil	3,286	49	41,565	11	4,867
Argentina	1,075	116	14,030	8	4,383
Others	1,651	117	21,328	8	3,060
Total	6,012	282	76,923	27	12,310
OCEANIA[e]	3,296	83	9,689	9	3,657
World Total	50,973	4,087	2,166,879	681	267,314

[a] See pp 51, 53 for sources of data

[b] Continental Europe, as here defined, includes the following islands Iceland, Azores, Madeira, Canaries, Spitsbergen, and all those in the Mediterranean except Cyprus. Mediterranean Africa includes Morocco (French, Spanish, and International Zones), Algeria, Tunisia, Libya, and Egypt, and Mediterranean Asia includes Turkey, Syria and Lebanon, Palestine and Trans-Jordan, and Cyprus

It was found impossible to assemble comprehensive world figures on productive, or even on arable, land. Data on cultivated land, shown in the second column of the table on page 52, represent land actually under crops, including tree and bush crops such as citrus fruit, and in some instances fallow land used in rotation. Acreage under native cultivation was included when known, but as far as possible duplications due to double cropping were excluded.

For a few countries information was limited to acreage under principal crops. In the case of the Arabian peninsula and Afghanistan, the cultivated area was arbitrarily estimated at two per cent of the total land. No data were available for a group of small countries and islands, accounting for about one half of one per cent of the total land in the world. This included Rio do Oro, Liberia, Nepal, and Greenland. Information was compiled by individual countries and then assembled by regions. The chief sources were the following agencies and publications:

U. S. Department of Commerce: *Foreign Commerce Yearbook, 1939;* Bureau of Foreign and Domestic Commerce, Division of International Economy; and Bureau of the Census, *Sixteenth Census Reports, 1940.*

The Statesman's Year-Book, 1940.

International Institute of Agriculture, *International Yearbook of Agricultural Statistics, 1939-40.*

Institute of Pacific Relations, *Economic Survey of the Pacific Area,* Part I, *Population and Land Utilization* (1942).

U. S. Department of Agriculture: *Foreign Agriculture,* No. 2 (December 1942), p. 19; *Foreign Agricultural Relations* (October 1942), p. 19; and Bureau of Foreign Agricultural Relations.

Thomas S. Githens and Carroll E. Wood, Jr., *The Food Resources of Africa* (1943).

U. S. Tariff Commission, *Foreign Trade of Latin America,* Part II Sec. 12 (1941) and *Report No. 151, Commercial Policies and Trade Relations of European Possessions in the Caribbean Area* (Sept. 21, 1943).

Pan American Union, *American Nation Series,* Nos. 6 and 14 (1941).

Colonial Office (British), *Agriculture in the West Indies,* Colonial No. 182 (1942).

H. L. Shantz, "Agricultural Regions of Africa," *Economic Geography* (January 1940).

Census of the Philippines, Vol. 2, *Summary, 1939,* p. 912.

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[c] Includes Greenland, St. Pierre, and Miquelon.

[d] Includes Colombia, Venezuela, British Guiana, French Guiana, and Surinam.

[e] Includes American Samoa, Australia and dependencies, British Solomon Islands, Fiji and dependencies, French Oceania, Gilbert and Ellice Islands, Guam, Japanese Mandated Islands, Nauru, New Caledonia and dependencies, New Hebrides, New Zealand and dependencies, and the Friendly Islands.

Almost half of Greater Europe's total land area, as the region is here defined, is actually on the Continent of Africa. This is because the political boundaries of African countries which border on the Mediterranean Sea, notably Algeria and Libya, extend so far south into the Sahara Desert. From every other point of view—cultivated land, population, income, railway mileage, and so forth—the influence of the African portion of Greater Europe is confined to only a narrow coastal strip along the Mediterranean, or, in the case of Egypt, along the Nile.

International trade in merchandise, 1938.

Inter-regional exports and imports were compiled from the League of Nations' *The Network of World Trade* (1942), Table 22, pp. 46-47, and Annex III, pp. 108-71. The figures refer to trade in merchandise, excluding gold and silver and, wherever possible, ships' stores and imports from fishing grounds. All data, expressed in current U. S. dollars, were adjusted by the League to represent c.i.f. frontier values—that is, to include transport costs such as ocean freight and insurance.

The seventeen trading regions shown in Table 22 of the League of Nations' publication have been combined as follows, to form eight world subdivisions: (Arabic numerals 1 to 17 refer to the League regional classifications.)

I. *Greater Europe:* (1) North Africa, (14) Continental Europe—industrial, (15) Continental Europe—non-industrial, and (16) Non-continental Europe.

II. *North America:* (4) Northern North America, and (5) United States.

III. *U.S.S.R.:* (13) U.S.S.R.

IV. *Asia:* (9) India, Burma, Ceylon, (10) Southeast Asia, (11) Japan, Korea, Formosa, and (12) China and other Continental Asia.

V. *Africa:* (2) South Africa, and (3) other Africa.

VI. *Middle America,* and VII. *South America,* combined correspond to the non-contiguous Latin America groups (6), (7), and (8) of the League, representing respectively mineral-producing, tropical agricultural, and non-tropical agricultural countries. Data for each of the several countries of Latin America were taken from Annex III of the League's study and grouped to conform with our two contiguous geographical divisions of that area.

VIII. *Oceania:* (17) Oceania.

Imports by country of origin are more likely to reveal the ultimate destination of shipments than are export data showing country of consignment. We have therefore used import statistics to determine both export and import regional totals. Theoretically, the total of world exports

and of imports should be identical Had we tabulated export data in the same manner we would have found substantially the same regional distribution of trade The figures, however, would generally be some 12 per cent lower, since exports are always valued f o b port of origin exclusive of freight and insurance.

Aggregate international imports in 1938 amounted to $24 580,000,000 Only 56 3 per cent or $13,850,000,000 represented trade *between* the eight major regions of the world. The balance, 43 7 per cent or $10,730,000,000 was accounted for by international trade *within* each of the eight regions The following table shows the breakdown of non-domestic trade into inter-regional and intra-regional groups

TOTAL INTERNATIONAL TRADE, BY MAJOR REGIONS, 1938
(In millions of United States dollars)

Region	Total Imports	Total Exports	Inter regional trade		Intra regional trade
			Imports	Exports	
Greater Europe	14,180	11,940	6,190	3,950	7,990
North America	3,010	4,480	2,220	3,690	790
U S S R	270	270	270	270	—
Asia	3,360	3,910	1,840	2,390	1,520
Africa	1,070	760	1,000	690	70
Middle America	910	1,040	730	860	180
South America	1,010	1,290	890	1,170	120
Oceania	770	890	710	830	60
World	24,580	24,580	13,850	13,850	10,730
British Isles[a]	4,370	2,700	2,770	1,630	[b]
United States	2,190	3,490	1,900	3,000	[c]

[a] These figures represent the total trade of countries classified by the League of Nations in non Continental Europe, including the United Kingdom, Eire, Iceland, Faroe Islands, and Spitsbergen The British Isles alone account for more than 99 per cent of this total trade

[b] Imports from other countries in Greater Europe were 1,600 million dollars, exports, 1,070 millions

[c] Imports from other North American countries were 290 million dollars, exports, 490 millions

World income.

Few economic factors are more difficult to evaluate on a rational comparative basis than real income earned around the world. Four years ago an Australian economist, Colin Clark, in *The Conditions of Economic Progress* (1940), made what is generally recognized as the best approach to date to a solution of this complex problem

From all available sources Clark determined or estimated the real income per worker for every part of the world To place this income on a roughly comparable basis, he expressed it in terms of international units, which he defined as equivalent to the average purchasing power in goods and services of $1 U. S. currency in the United States during the decade

1925-34. Allowance was made, in converting foreign currencies to international units at the then prevailing rates of exchange, for differences in national price levels relative to the United States

In Clark's summarized distribution of World Income[1] totals were given by the author for 15 countries or groups of countries arranged partly on a geographical and partly on an economic basis. Additional details are given

WORLD INCOME BY MAJOR REGIONS AND COUNTRIES, 1925-34[a]
(In international units)

Region	Annual Average (In billions)		Average per Worker (In units)
GREATER EUROPE.			
British Isles	22.7		1,002
Germany and Austria	19.0		639
France	12.5		684
Other continental Europe	34.5		423
Mediterranean Asia and Africa	2.6[b]		
	——	91.3	
NORTH AMERICA.			
Canada	5.1		1,337
United States	65.6		1,381
	——	70.7	
U.S.S.R.		17.5	320
ASIA, EXCLUDING MEDITERRANEAN			
Japan	8.1		353
China	22.7		100–120
British India	15.0		200
Netherlands Indies	2.6		
All Others	4.8[c]		
	——	53.2	
AFRICA, EXCLUDING MEDITERRANEAN			
South Africa	0.9		276
Others	3.8[c]		
	——	4.7	
MIDDLE AMERICA		2.6	
SOUTH AMERICA, EXCLUDING NORTH COAST			
Argentina, Uruguay, Chile, and Brazil	10.6		
Others	0.6[b]		
	——	11.2	
AUSTRALIA AND NEW ZEALAND		3.2	1,017
World Total		254.4	

[a] Based on Clark's population data and income estimates, in *The Conditions of Economic Progress*, pp. 40–56 Income per worker omitted for areas where data are least reliable See also note on p. 15

[b] Clark, on page 56, indicated a total income of 7.3 billion international units for the following combination of countries Mediterranean Asia and Africa, Philippines, Hawaii, South Africa, and the smaller countries of Latin America A total of 0.9 billion was given on page 40 for South Africa, leaving 6.4 billions to be divided among the others This remainder was allocated on the basis of the following percentage distribution of population Mediterranean Asia and Africa, 41, Philippines, 10, Middle America, 39, and South America (excluding Argentina, Uruguay, Chile, and Brazil), 10

[c] A similar aggregate figure of 8.0 billions, estimated by Clark for certain lesser countries of Asia, Africa, and Oceania, was divided as indicated above in proportion to the following population distribution "Rest of Asia, 52 per cent, "Rest of Africa," 47 per cent, and "Rest of Oceania," 0.8 per cent

[1] *The Conditions of Economic Progress*, p 56

for several individual countries in tables on pages 40 and 54 which, together with estimates described in footnotes to the accompanying table, made it possible to rearrange the countries or regions into a form consistent with our geographical divisions of the world.[2]

Factory output by major regions, 1937.

A comparison of world industrial activity is complicated by the widely differing sense in which the term "industrial production" is used and the varying methods employed for computing it. Some countries include almost the entire range of national industry; others limit it to important branches considered representative.

Industrial indexes in general are based on actual data of production. In some cases extensive reliance is placed on indirect measures of activity, such as man-hours worked, consumption of raw materials, and so forth. Mining, building, and electric power output are generally included along with manufacturing industries.

In the accompanying table we have eliminated building construction and mining wherever possible. Hence the industrial index shown here represents primarily manufacturing and, in some instances, electric power production. In Latin America census figures for manufacturing do not include output of the sugar mills of Cuba; or of the copper smelters and refineries of Chile but meat packing plants are usually covered. While petroleum refining is generally represented, as for instance in U. S. Federal Reserve Board manufacturing index, it has not been possible to include it for the Netherlands West Indies, Iraq, Iran, and some other countries. Very small manufacturing establishments are generally excluded from the industrial census. Limits vary from country to country. In the United States plants producing less than $5,000 worth of goods per annum are not counted.

Two fairly comprehensive surveys have been made to determine the relative importance of various countries with respect to the volume of industrial production. Both of them, unfortunately, are now badly out of date. The German Institut für Konjuncturforschung in *Vierteljahrshefte zur Konjuncturforschung*, Sonderheft 31, *Die Industriewirtschaft*, 1933, has published the most complete set of data, showing the world proportion of industrial manufacturing and mineral output for each of 38 countries in 1928. Practically every country having any substantial factory output, with the possible exception of China, is included in this 1928 survey.

An annual survey of *World Production and Prices* was published by the League of Nations for a period of years. In the 1935-36 edition, page 22, the relative manufacturing activity of 24 countries was compiled for the

[2] The more recent study by the same author, *The Economics of 1960* (1942), deals primarily with potential, rather than actual, world income and hence is not applicable for our purposes here.

Statistics Used in Computing 1937 Geographical Distribution of World Factory Output

Region and Country	Relative Importance in 1928: Ratio of Manufacturing to Total Industry in Each Country[a] (1)	Per Cent of World Total Manufacturing and Mining[a] (2)	Manufacturing Only: Unadjusted (1) times (2) (3)	Manufacturing Only: Adjusted to 100 Per Cent (4)	Index Numbers of Manufacturing, 1929 = 100[b]: 1928 (5)	1937 (6)	Ratio 1937 to 1928 (7)	Relative Importance in 1937: Unadjusted (4) times (7) (8)	Adjusted to World Total Equals 100 (9)
Europe									
Germany (including Saar)	.84	11.70	9.83	11.97	101	121	1.20	14.36	10.33
Great Britain	.75	9.26	6.95	8.46	95	127	1.31	11.34	8.16
France	.92	7.00	6.44	7.84	94	87	.93	7.29	5.25
Italy	.95	3.15	2.99	3.64	91	98	1.08	3.93	2.83
Czechoslovakia	.75	1.60	1.20	1.46	97	97	1.00	1.46	1.05
Belgium	.80	1.10	.88	1.07	99	94	.95	1.02	.73
Netherlands	.84	1.00	.84	1.02	96	109	1.14	1.16	.83
Sweden	.90	.85	.77	.94	89	149	1.67	1.57	1.13
Poland	.78	.75	.59	.72	99	114	1.15	.83	.60
Austria	.87	.60	.52	.63	98	103	1.05	.66	.48
Denmark	1.00	.35	.35	.43	94	136	1.45	.62	.45
Hungary	.94	.36	.34	.41	98	132	1.35	.55	.40
Greece	.94	.25	.24	.29	98	151	1.54	.45	.32
Norway	.93	.25	.23	.28	91	130	1.43	.40	.29
Finland	1.00	.15	.15	.18	103	156	1.51	.27	.19
Latvia	1.00	.15	.15	.18	81	161	1.99	.36	.26
Others[c]	.78	3.20	2.50	3.04			1.00	3.04	2.19
Total	—	41.72	34.97	42.58	—	—	—	49.31	35.49
North America									
United States	.86	44.80	38.53	46.92	91	103	1.13	53.02	38.16
Canada	.88	2.22	1.95	2.37	96	104	1.08	2.56	1.84
Alaska and Hawaii (1939)	—	—	—	—	—	—	—	.16[d]	.12
Total	—	—	—	—	—	—	—	55.74	40.12
U.S.S.R.	.78	4.65	3.63	4.42	79[e]	372[e]	4.71[e]	20.82	14.99
Asia									
Japan	.82	2.35	1.93	2.35	98[f]	190[f]	1.94	4.56	3.28
India	.85	1.30	1.11	1.35			1.36[g]	1.84	1.32
Total	—	—	—	—	—	—	—	6.40	4.60
Africa	—	—	—	—	—	—	—	.93	.67
Middle America	—	—	—	—	—	—	—	.65[d]	.47
South America	—	—	—	—	—	—	—	3.22[d]	2.32
Oceania	—	—	—	—	—	—	—	1.86[d]	1.34
Total for countries listed	—	97.04	82.12	100.0	—	—	—	—	—
World Total	—	—	—	—	—	—	—	138.93	100.0

period 1925-29, also figures on combined output of manufacturing and mining for these countries.

Great changes have taken place in the relative volume of factory output in various countries since 1928-29. This is attested both by index numbers of industrial production compiled by the League of Nations, and other sources. (See the League's *Statistical Year-Book* for recent years.)

In relative industrial activity Soviet Russia and several smaller countries have forged ahead amazingly while some of the more important countries have either actually declined since 1928, or increased but slightly. So pronounced are these divergent trends that a complete revision of the earlier figures is essential if we are to obtain a realistic world comparison of current industrial activity.

In 1938 industrial production in the United States was depressed, while that in Europe was artificially stimulated by the approach of war. For this reason we have selected 1937 as a better year for our comparison.[8]

The methodology employed in obtaining the 1937 distribution is shown in some detail in the two tables herewith. In general the procedure was as follows: a distribution of factory output only was obtained for 1928 covering countries in Europe, North America, U.S.S.R., and Asia. These figures, representing the relative importance of each, were then brought up to date by multiplying the ratio of change in manufacturing from 1928 to 1937 by the relative weights (percentage distribution) in 1928.

To determine the relative importance of Alaska, Hawaii, and of countries in Latin America, Africa, and Oceania the value added by manufacturing was first found by subtracting from the gross value of output the cost of raw materials, fuel, and so forth used or consumed in the produc-

[8] From 1937 to 1938 output of manufactured goods in the United States decreased 23 percent. In Russia for the same period output is reported to have increased about 10 per cent.

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[a] From *Vierteljahrshefte zur Konjunkturforschung, Die Industriewirtschaft*, pp. 51-53.

[b] Computed principally from figures in League of Nations, *Statistical Yearbook* for recent years except where otherwise noted. For several countries where the general index of industrial production included mining and building construction the figures were revised, wherever possible, to exclude these industries. The only countries for which mining could not be excluded from the index numbers are Austria, Sweden, Norway, Finland, and U.S.S.R.

[c] Includes Luxembourg, Switzerland, Spain, Yugoslavia, Rumania, Portugal, Bulgaria, and Estonia. Production in Spain probably decreased from 1928 to 1937, but it is assumed that there was no change in the level of output for the eight countries combined, since no data are available.

[d] Computed from the relation between net value of output in these areas and corresponding data for the United States, expressed as relatives with the United States equal to 53.02. (See list p. 60 for details.)

[e] The number for 1928 was computed from League of Nations, *Statistical Yearbook 1937/38*, while the 1937 index is from a new series published in the same, *1940/41*. The increase of 371 per cent from 1928 to 1937 is believed to be conservative with respect to factory output since the general index includes mining which, judging from output of coal and petroleum, failed to increase as much as manufacturing. Real output of all heavy industry expressed in rubles at 1926-27 prices increased more than 420 per cent from 1928 to 1937. See Maurice H. Dobb, *Soviet Economy and the War* (reprint January 1942), p. 28. In 1937 Russia produced 68 per cent more pig iron and 34 per cent more steel than United Kingdom. *Foreign Commerce Yearbook*, 1939, pp. 124, 132.

[f] Index numbers for Japan are based on 1930=100. The 1930 figure was calculated from *Vierteljahrshefte zur Konjunkturforschung, Die Industriewirtschaft*, p. 67.

[g] Based on changes in paper output, mill consumption of raw cotton, exports of jute bags and cloth, and iron and steel output, weighted by number of workers employed in these industries. The basic data were obtained from *Statesmen's Yearbook*, and U. S. Dept. of Commerce, *Foreign Commerce Yearbook*, for various years.

tive process. This value, summarized for each area from the list given below, was then expressed in per cent of world total as indicated in column 9 and in footnote (d) of the preceding table.

Country and Year	Value Added by Manufacturing (In millions of dollars)[4]
United States (1937)	25,174
Alaska (1939)	18
Hawaii (1939)	58
Union of South Africa (1936-37)	421
Southern Rhodesia (1941)	21
Mexico (1940)	115
Colombia (1939)	63
Cuba (1939)	42
Venezuela (1936)	40
Puerto Rico (1939)	35
Dominican Republic (1939)	15
Argentina (1937)	603
Brazil (est.) (1940)	762
Chile (1937)	108
Uruguay (1937)	57
Australia (average of 1936-37 and 1937-38)	737
New Zealand (average of 1936-37 and 1937-38)	147

Had 1938 been taken as the reference year, rather than 1937, the United States' share of world factory output would decrease some six points, from 38 to 32 per cent; while Soviet Russia's share would increase three points, from 15 to 18 per cent. On a national basis Soviet Russia was second only to the United States in industrial output, prior to the war. In *consumer goods*, however, British output exceeded Russian.

World railway and highway mileage and motor vehicle registrations.

A world-wide comparison of even such ordinarily dependable figures as railway mileage is not altogether free from qualification. No uniform practice is followed to distinguish route miles from miles of double or parallel tracks. The figures shown in the table on page 61 were compiled from U. S. Department of Commerce, *Foreign Commerce Yearbook*, 1939; the *Statesman's Yearbook* (various years); and unpublished government reports. In general they represent as far as possible only main-line tracks, or railway route miles operated in 1938 or other recent prewar year.

[4] From the following sources United States, Alaska, Hawaii, and Puerto Rico from U S Dept of Commerce, *Statistical Abstract of the United States, 1941*, Mexico, Colombia, Venezuela, Brazil, and Uruguay from *Inter-American Affairs 1942* (1943), p. 198 (figure for Brazil estimated from gross value of output, converted from milreis to dollars at $0 06056, assuming that net value represents 50 per cent of gross value of output), Africa, Oceania, and Dominican Republic from *Statesman's Yearbook* for various recent years, and Argentina and Chile from *Inter-American Statistical Yearbook, 1940*, p. 125. (The figure given for Chile has been increased 50 per cent to adjust for under-reporting.)

World Railway and Highway Mileage, and Motor Vehicle Registrations

Region	Route Miles[a]		Route Miles per 1,000 Sq. Miles[b]		Number of Motor Vehicles
	Railway 1938	Highway 1940	Railway	Highway	Jan. 1, 1940
GREATER EUROPE					
British Isles	25,880	242,090	213.9	2,000.7	2,497,000
Continental Europe	148,360	1,652,760	77.1	858.6	6,195,000
Mediterranean Africa	9,330	72,530	4.4	34.0	130,000
Mediterranean Asia	5,970	36,340	14.8	90.2	38,000
Total	189,540	2,003,720	41.3	437.1	8,860,000
NORTH AMERICA					
Canada and Newfoundland	44,640	605,200	12.2	165.2	1,426,000
United States	248,040	3,065,000	83.3	1,029.6	31,010,000
Alaska	700	2,090	1.2	3.7	4,000
Hawaii	290	2,040	48.3	340.0	67,000
Total	293,670	3,674,330	40.7	509.1	32,507,000
U.S.S.R.	51,940	1,682,000	6.4	205.7	801,000
ASIA, EXCLUDING MEDITERRANEAN					
Japan proper	15,190	591,770	102.6	3,998.4	186,000
China (including Manchuria and dependencies)	13,160	86,479	2.9	18.9	80,000
India (including French and Portuguese India)	41,470	319,130	26.3	202.2	115,000
Others	20,770	180,631	5.3	45.8	303,000
Total	90,590	1,178,010	8.9	115.1	684,000
AFRICA, EXCLUDING MEDITERRANEAN	33,600	393,390	3.6	41.8	540,000
MIDDLE AMERICA					
Mexico	12,370	56,920	16.3	75.1	105,000
Central America	2,310	11,240	10.4	50.4	26,000
West Indies	4,950	20,750	54.4	228.0	112,000
North Coast of South America	3,030	21,220	3.1	22.1	69,000
Total	22,660	110,130	11.1	54.1	312,000
SOUTH AMERICA, EXCLUDING NORTH COAST					
Brazil	21,170	129,060	6.4	39.3	181,000
Argentina	27,240	253,110	25.3	235.5	273,000
Others	12,710	78,880	7.7	47.8	144,000
Total	61,120	461,050	10.2	76.7	598,000
OCEANIA	32,750	581,690	9.9	176.5	1,120,000
World total	775,870	10,084,320	15.2	197.8	45,422,000

[a] See text for sources, and p. 52 for countries included in regional subdivisions.
[b] See Col. 1, of table, p. 52 for total area.

Statistics of highway mileage are from the U. S. Department of Commerce *Industrial Reference Service*, June 1941, Part 9, No. 5. They

represent all types of roads (exclusive of city streets), including many below the standards of secondary roads in the United States. Were it possible to compare only improved and hard-surfaced roads, the proportion in Greater Europe and North America would be even greater. Reducing railway and highway route mileage to an equivalent area basis emphasizes the relatively high concentration of roads and railways in the British Isles —twice that in the United States. In Japan the road density is the highest in the world and the railway mileage per square mile is second only to the British Isles.

The relative volume of travel by railway and by highway on a worldwide basis is impossible to determine. Some information on annual railway passenger-miles is given in the *Statistical Year-Book of the League of Nations, 1935-36*, page 205. The *Foreign Commerce Yearbook*, U. S. Department of Commerce, contains similar figures for a number of countries. The following table summarizes what recent data are available on railway passenger-miles on a regional world basis.

Region	Railway Passenger-Miles in 1934 (In Millions)	
Greater Europe:		
British Isles and Continent (incomplete)	64,622	
Mediterranean Africa	1,301	
		65,923
North America:		
Canada	1,530	
United States[a]	18,069	
		19,599
U.S.S.R.		44,366
Asia (excluding China)		37,655
Africa (Nigeria only)		149
Middle America (Mexico only)		716
South America (Chile and Uruguay)		724
Australia		2,845
World total—incomplete		171,977

The table on page 61 also shows the registration of passenger cars, buses, trucks, and diesel vehicles throughout the world on January 1, 1940, as given in U. S. Department of Commerce *Automotive World News*, May 20, 1940, Vol. 2, No. 13, pages 119-22. As of that date there were 45,422,000 motor vehicles of all types in use, of which 68.5 per cent or 31,104,000 were in the United States and Territories and the balance of 14,318,000 or 31.5 per cent were scattered throughout the rest of the world.

[a] In the United States 1934 was a depression year, as it was in many other countries. Railway passenger travel fell to almost half (58 per cent) that of 1929. By 1941 it had increased to 30,317 million passenger-miles. The passenger-miles on United States domestic *airlines* in 1934 amounted to 188 millions, increasing to 1,492 millions in 1941.

Four fifths of the world total registrations were passenger cars. In the United States 84.4 per cent of all motor vehicles were privately-owned passenger cars, while for all other countries the average was only 67.7 per cent. Outside the United States 36 5 per cent of all motor vehicles were American types. During the decade 1930-40 the number of automobiles in use in the world increased by 10 million units.

The average number of persons per motor vehicle in selected countries and in the eight world regions at the start of 1940 was as follows—arranged according to motor vehicle density.

Selected Countries	Number of Persons per Motor Vehicle (January 1940)
United States	4
New Zealand	6
Australia	8
Canada	8
France	17
British Isles	20
Denmark	23
Union of South Africa	27
Germany	41
Argentina	51
Eight Principal Regions	
North America	4
Oceania	9
Greater Europe	50
South America	129
Middle America	173
Africa	212
U.S.S.R.	213
Asia	1,689
World Average	48

The number of cars a community possesses at any given time is, of course, the end product of a large number of factors. The primary demand is for transportation service; the sale of a new passenger car to a consumer is a derived demand. The results of a general analysis of the various factors which influence the demand for automobiles were reported in *The Dynamics of Automobile Demand* (1939), based upon papers presented at a joint meeting of the American Statistical Association and the Econometric Society, December 27, 1938.

Some of the factors identified were: improvement in the product; lowering of the real price; decrease in cost of operation; increased mileage of good roads, greater availability of service; increase in population, improved standards of living. Factors affecting year-to-year fluctuation in new car sales included: general business activity and national income (con-

sidering both the level and direction of change); cost of living in relation to national income; and numerous other more technical factors.

A demand formula was developed in terms of "supernumerary" income, defined as disposable income less an estimated allowance for the cost of living. This formula agreed very well with the actual sales experience of the industry. A number of alternative formulas, however, could also be devised that would give a fairly good statistical explanation of fluctuations in sales.

The demand for transportation service is a complex multi-factor phenomenon in which national income, the cost and utility of the service, the psychological atmosphere, and a multitude of other influences all enter in. Nevertheless, on a regional basis, the number of automobiles registered in the various regions does give some insight into the relative desire for individual transportation in that area, combined with the relative ability and opportunity to satisfy the desire.

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